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KESTERSON PROGRAM

KESTERSON RESERVOIR
BIOLOGICAL MONITORING REPORT

U.S. Bureau of Reclamation
Mid-Pacific Region

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EXECUTIVE SUMMARY

This document includes a report on the results of biological monitoring conducted at Kesterson Reservoir from the fall of 1988 to the fall of 1989. Also contained in this document is the Kesterson Reservoir Biological Monitoring Plan for 1990.

The drying and filling of Kesterson Reservoir has converted the site to upland habitat consisting of grassland, filled, and open habitats. When plants from different macro habitats are pooled, selenium levels in vegetation are generally low, below 3 ppm, with the exception of mustard. The geometric mean selenium level in mustard was 14 ppm, about 3 to over 5 times higher than the means of most other plants, which ranged from 2.7 ppm in salt grass to 4.4 ppm in prickly lettuce. Plants collected from open (unfilled former emergent marsh) habitats tended to have higher selenium levels than plants from other habitat types, although this was not true in all species. The higher selenium levels found in vegetation from this habitat may reflect the higher water extractable selenium in the soil in these sites.

Selenium levels in invertebrates reflect the selenium concentrations in their diet. Selenium levels range from about 5 ppm in grasshoppers and aerial insects to about 55 ppm in sowbugs. Overall, invertebrate selenium levels were about 2 to 3 times higher than plant selenium levels. The high selenium levels in sowbugs are apparently related to the similarly high selenium levels that have been found in soil litter where sowbugs live and forage. Although sowbugs have not been found in the digestive tracts of birds and mammals examined from Kesterson Reservoir, the importance of the litter-based food chain should not be discounted.

Since the completion of filling, bird species using Kesterson Reservoir have changed from mainly aquatic species to terrestrial species. Prior to filling, the types of birds using Kesterson Reservoir were primarily ducks, coots, and shorebirds. Filling reduced or eliminated the use of Kesterson Reservoir by most of these species. Terrestrial species that would be expected to use any upland habitat in that area, such as western meadowlarks, horned larks, sparrows, barn swallows, northern harriers, and red-tailed hawks, are now using the Reservoir for nesting, resting, and/or feeding.

Tricolored blackbirds, which have nested at Kesterson Reservoir in the past, did not nest in Kesterson Reservoir in 1989. Because of the lack of suitable tricolored blackbird nesting habitat, it is not expected that they will nest in the Reservoir in the future.

Among other upland bird species, western meadowlarks, killdeer, barn swallows, and mourning dove all nested successfully at Kesterson Reservoir in 1989. Eggs were collected from nests of these species, and although selenium levels continued to be elevated above the level expected in eggs from uncontaminated areas, no selenium associated abnormalities or mortality was found. This lack of embryotoxicity may be caused by changes in the matrix of contaminants found at Kesterson Reservoir since delivery of drainwater was discontinued, other changes in environmental conditions at Kesterson Reservoir, or species-specific selenium embryotoxic relationships.

Adult western meadowlarks collected from Kesterson Reservoir in 1989 had slightly lower liver selenium levels than meadowlarks collected in 1988. Although these selenium levels are still high enough that reproductive problems might be expected, reproductive problems have not been observed.

Geometric mean selenium levels found in small mammals in 1989 ranged from 1.8 ppm in valley pocket gophers to 21.4 ppm in ornate shrews. These levels were generally similar to levels found in mammals in 1987 and 1988, when the same species were compared. Only western harvest mice collected in 1987, which had a geometric mean selenium level of 4.1 ppm, were significantly different from western harvest mice collected in 1989, which had a geometric mean selenium level of 6.3 ppm. No adverse reproductive impacts were observed in small mammals collected from Kesterson Reservoir in 1989. No significant differences in selenium levels were found between male and female, reproductive and non-reproductive, or adult and juvenile small mammals. Reproductive success in western harvest mice was not analyzed due to the small number of non-reproductive harvest mice collected. Species differences were found in selenium levels; shrews and voles had the highest overall selenium concentrations and house mice and valley pocket gophers had the lowest. The differences in the levels of selenium found in different small mammal species appear to be related to both diet (as in insectivorous shrews) and environment (as in voles, many of which live and forage in the litter in open areas).

Gopher snakes collected from Kesterson Reservoir had a wide range of selenium levels, but gross necropsy revealed no adverse effects of selenium. The geometric mean selenium concentration in livers collected in 1989 were lower than Ohlendorf et al. (1988) reported in snakes collected from Kesterson Reservoir in 1984 and 1985.

High selenium concentrations in small mammals and reptiles may impact predatory birds and mammals, such as hawks and the endangered San Joaquin kit fox, that feed on them. In night surveys conducted in 1989 at Kesterson Reservoir, no kit fox were sighted; during predator collections, no kit fox sign was observed at any traps. In fact, in 1989 there was very little use of Kesterson Reservoir by

mammalian predators other than coyotes. Therefore, it is unlikely that the elevated levels of selenium in the small mammal prey base at Kesterson Reservoir have had a negative effect on San Joaquin kit foxes.

Three predators, two barn owls and a coyote pup, were salvaged from Kesterson Reservoir and examined. In one barn owl's liver, the selenium concentration was 12 ppm; although this liver selenium was elevated, the cause of death was diagnosed as trauma. The other two predators had low liver selenium concentrations (3.6 ppm in the barn owl and 3.4 ppm in the coyote), and the cause of death could not be determined.

Based on the most recently completed sampling, some plants, invertebrates, reptiles, birds, and mammals continue to have elevated selenium levels. However, no adverse impact to wildlife has been observed since completion of filling in November 1988. Monitoring is continuing to document changes in selenium levels and any wildlife impacts that may occur.

Chapter 1
INTRODUCTION

This report presents the results of the biological monitoring program conducted at Kesterson Reservoir between October 1988 and October 1989. Components of the monitoring included 1) habitat mapping, 2) vegetation/invertebrate/surficial/soil sampling and analyses for contaminants; 3) bird censusing, 4) bird nesting survey and reproduction analyses; 5) bird collection and analyses for contaminants; 6) reptile and amphibian collections and analyses for contaminants; 7) small mammal collections and analyses for contaminants; 8) mammalian predator collections and analyses for contaminants, and 9) night surveys. The objectives of the program were defined as follows by the Central Valley Regional Water Quality Control Board as stated in Order No. WQ 88-7:

1. Assess the impact of Kesterson Reservoir on local and migratory wildlife.
2. Provide a basis for adjusting Kesterson Reservoir management.
3. Verify the effectiveness of cleanup actions at Kesterson Reservoir.
4. Provide a basis for modifying future biological monitoring.

Chapter 2
HABITAT MAPPING

OBJECTIVES

The objectives of the habitat mapping were to identify and map the major habitat types present at Kesterson Reservoir during the 1989 monitoring periods.

METHODS

Within 1 month of each sampling period, 1:24,000 scale aerial photographs were taken of Kesterson Reservoir. Habitat types were mapped by aerial photography interpretation. The habitat maps were finalized by ground-truthing to verify correct habitat identifications. In addition, U.S. Bureau of Reclamation (USBR) biologists noted the locations and extent of any surface water that formed on Kesterson Reservoir throughout the year.

RESULTS

HABITAT TYPES

Three upland macro habitat types were present on Kesterson Reservoir during the 1988/1989 sampling period (Figure 2-1):

- **Grassland**--unfilled areas dominated by salt grass covered about 31 percent of the Reservoir.

- **Filled**--former wetland areas newly filled with dirt. These areas were dominated by annual plant species such as burning bush and annual grasses. Filled habitat covered about 56 percent of the Reservoir.

- **Open**--former cattail areas not filled. These areas were dewatered and disced. Open areas were sparsely vegetated with burning bush, prickly lettuce, and clover. Open habitat covered about 13 percent of the Reservoir.

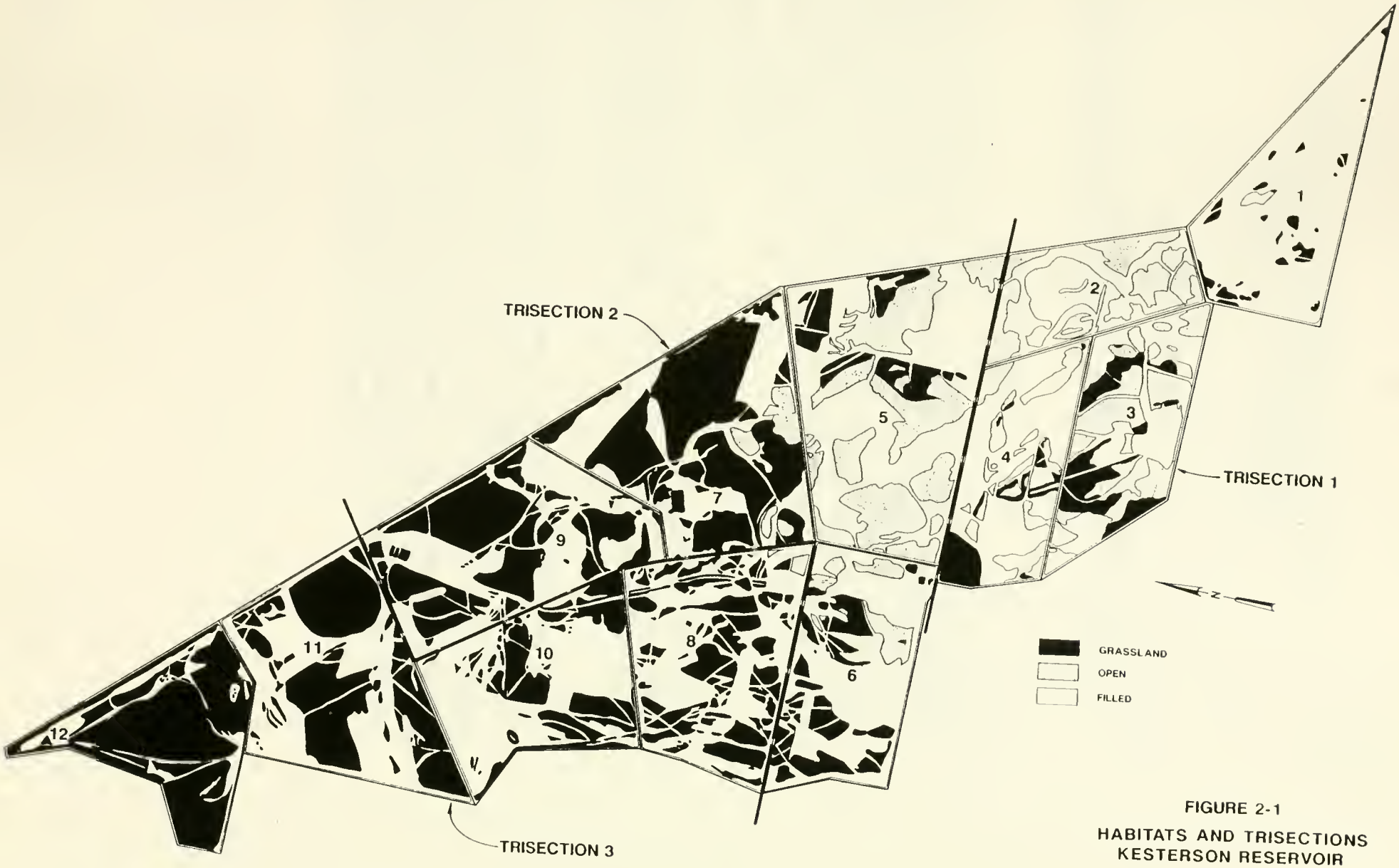

FIGURE 2-1

HABITATS AND TRISECTIONS
KESTERSON RESERVOIR

Chapter 3
VEGETATION/INVERTEBRATE/SOIL/SURFICIAL SAMPLING AND ANALYSES FOR CONTAMINANTS AND ABUNDANCE

OBJECTIVES

The primary objective was to determine the level of selenium in vegetation, invertebrates, soil, and water at Kesterson Reservoir.

METHODS

Samples were collected during the two peak periods of wildlife exposure to contaminants at Kesterson Reservoir. These periods were the overwintering period from January to the middle of February 1989, and the reproductive period from the middle of March 1989 to the end of June 1989. In addition to these two periods, samples were also collected during two interim periods: fall samples were collected in early December 1988 and summer samples were collected in August 1989. This resulted in a total of four sample collection periods.

SAMPLE LOCATIONS

For sampling purposes, Kesterson Reservoir was divided into three trisections. Trisection 1 consisted of the southern ponds 1, 2, 3, and 4; Trisection 2 consisted of the central ponds 5, 6, 7, and 9; Trisection 3 consisted of the northern ponds 8, 10, 11, and 12 (Figure 2-1).

The aerial photographs, along with presampling ground reconnaissance, were used to choose sampling stations. Whenever it was possible, sampling stations remained the same from period to period. Samples were taken from each of the three habitat types: grassland, filled, and open. Three sites were sampled within each trisection during the Fall 1988 and Winter 1989 sampling periods. Six sites were sampled during the Spring and Summer 1989 sampling periods to increase the sample size for statistical comparisons. The same sample stations were used for plant, invertebrate, and soil sampling.

SAMPLING METHODS

Vegetation

Plant species that were most dominant Reservoir-wide were chosen to be sampled on the basis of presampling reconnaissance with USFWS personnel. Above-ground plant material was collected by clipping sections from living plants with shears or pinching sections off with fingers. Seeds were collected separately when they were present. Samples were collected from at least three different plants at the sample station to provide a minimum of 2 g wet weight of seed or vegetative material for each species.

Not all plant species were available every sampling period. During the fall sampling period, which occurred soon after completion of filling, no live vegetation was found in either the filled or open habitats. The dominant plants identified for collection were alkali heath and salt grass growing in grassland habitat. During the winter sampling period clover began growing in the open habitats and annual grass began growing in the filled habitats; these were collected for selenium analysis. Salt grass and alkali heath were again collected from the grassland habitats in the winter. During the spring sampling period a variety of vegetation had started to grow in all three habitat types. Salt grass, alkali heath, alkali weed, and prickly lettuce were chosen for collection from grassland habitats; annual grass, burning bush, clover, mustard, and prickly lettuce were chosen for collection from filled habitats; and alkali heath, alkali weed, annual grass, burning bush, clover, and prickly lettuce were chosen for collection from open habitats. Salt grass seeds were collected from the grassland habitats, clover seed and annual grass seed were collected from both the filled and open habitats during the spring sampling period. During the summer sampling period alkali heath, alkali weed, burning bush, and prickly lettuce were collected as the dominant vegetation in filled and open habitats.

Invertebrates

Terrestrial invertebrates were collected with pitfall traps, sweep nets, and by hand. Pitfall traps were used to collect ground foraging invertebrates. These traps were set up at each sample station, in each macro habitat. Moist soil and vegetation were placed at the bottom of the traps and a cover was place about 1.5 cm above each trap for protection from the elements.

Sweep nets were used to collect terrestrial invertebrates and spiders that forage in the vegetation above the ground and to collect aerial insects. These invertebrates were collected from areas around each station.

Active searching within a 25-foot radius of the center of the station was also used as a collection method. Each station was searched by turning over rocks, boards, and debris found at the station, and the area beneath plywood placed at stations was turned over and searched for invertebrates.

Soil

Soil samples were collected at each sample station by combining three samples taken within a 25-foot radius of the station center. The soil was sampled by inserting a core about 15 cm into the soil. Samples were analyzed by Lawrence Berkeley Laboratory (LBL) for water extractable selenium.

Surficial Water

Water samples were taken by USBR biologists from the center of persistent pools. Selenium analysis was performed by USBR.

RESULTS

VEGETATION

A list of all plant species identified growing on Kesterson Reservoir is presented in Appendix A-1 and tables presenting the results of selenium analyses are in Appendix B-1. The geometric mean of the selenium levels[1] in samples of different plant species from different habitat types are generally low to moderate, with the exception of mustard (Table 3-1), and the geometric mean selenium level ranged from 1.3 ppm (n=27; range=0.2-9.4) in annual grass from filled habitat to 8.4 ppm (n=27; range=1.4-27) in clover from open habitat. Mustard collected from filled habitat had a significantly[2] higher geometric mean selenium level of 13.6 ppm (n=18; range=2.9-82) than other plants. Selenium concentrations in alkali heath, alkali weed, and salt grass were significantly higher than the same species collected from San Luis Wildlife Refuge as controls which all had geometric mean selenium levels under 0.1 ppm.

The geometric mean selenium levels in plant seeds ranged from 1.1 ppm (n=18; range=0.2-7.0) in annual grass seed from filled habitat to 8.2 ppm (n=18; range=2.9-25) in clover seed samples collected from open habitat. The geo-

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[1]All selenium levels presented in this report are on a dry weight basis.

[2]Comparisons were made using the Mann-Whitney U Test (p=0.05) (Zar 1974).

Table 3-1
KESTERSON RESERVOIR
1989 PLANT SELENIUM CONCENTRATIONS
(ppm dry weight)

	N	GEOMETRIC MEAN	RANGE
GRASSLAND			
alkali heath	36	3.8	1.1 - 32
alkali weed	18	3.5	0.9 - 8.5
prickly lettuce	18	6.1	1.2 - 20
salt grass	36	2.7	0.6 - 8.6
salt grass seed	18	1.2	0.2 - 4.7
FILLED			
alkali heath	15	4.1	0.4 - 28
alkali weed	24	5.6	1.0 - 29
annual grass	27	1.3	0.2 - 9.4
annual grass seed	18	1.1	0.2 - 7.0
burning bush	25	2.8	0.1 - 16
clover	17	1.4	0.2 - 13
clover seed	18	2.2	0.3 - 18
mustard	18	14	2.9 - 82
mustard seed	18	4.8	1.5 - 13
prickly lettuce	18	4.3	1.3 - 18
OPEN			
alkali heath	17	2.6	0.4 - 10
alkali weed	15	2.4	0.9 - 9.1
annual grass	17	6.8	1.2 - 38
annual grass seed	17	6.1	2.8 - 13
burning bush	36	2.1	0.3 - 16
clover	27	8.4	1.4 - 27
clover seed	18	8.2	2.9 - 25
prickly lettuce	36	3.9	0.6 - 16

metric mean selenium concentration in mustard seeds was 4.8 ppm (n=18; range=1.5-13) which was not significantly different than the selenium levels found in other seeds.

There was no significant difference found in plants from different trisections (except salt grass from Trisection 1 and 2), but the general trend of higher selenium levels in the south and lower levels in the north were observed. Significant differences could be found between some plant species, although some plants are habitat-specific and the differences may be related to habitat differences rather than species differences. Significant differences were found within species between habitats. Annual grass, annual grass seed, clover, and clover seed samples from open habitats were significantly higher than the same species from filled habitats. Also, in Trisection 2, selenium levels in prickly lettuce samples collected from grassland habitats were significantly higher than selenium levels in prickly lettuce samples collected from filled habitats.

Seasonal differences of selenium levels were not found in vegetation at Kesterson Reservoir. Concentrations of selenium in salt grass collected in 1987 and 1988 and in alkali weed collected in 1988 were compared for differences, although the overall concentrations were low. The geometric mean for salt grass collected in 1989 was 2.7 ppm (n=36; range=0.6-8.6) and was significantly higher than the total salt grass collected in 1988, which had a geometric mean selenium concentrations of 2.0 ppm (n=54 range=.05-13), not significantly different from 1987 salt grass samples which had a geometric mean selenium concentration of 2.9 ppm (n=12; range=1.1-8.0). Alkali weed collected Reservoir-wide in 1989 had a geometric mean selenium concentration of 3.9 ppm (n=57; range=0.9-29), which was significantly higher than alkali weed collected Reservoir-wide in 1988 which had a geometric mean selenium concentration of 2.1 ppm (n=50; range= <0.2-9.2).

INVERTEBRATES

The results of selenium analysis of invertebrates from Kesterson Reservoir are presented in Appendix B-2. Geometric mean selenium concentrations (Table 3-2) varied from 4.4 ppm (n=55; range=0.7-25) in grasshoppers to 12.6 ppm (n=59; range=0.1-78) in beetles; the geometric mean selenium level in sowbugs was 57.7 ppm (n=33; range=23-120). Beetles (<0.2 ppm), sowbugs (<0.3 ppm), and spiders (<0.4 ppm) collected from SLWR were all significantly lower in selenium than invertebrates collected at Kesterson Reservoir. Invertebrate selenium levels, excluding sowbugs, were 2 to 3 times higher than levels found in plants. Selenium levels varied greatly in invertebrates collected. Sowbugs seem to accumulate selenium more readily and had significantly higher selenium concentrations than other invertebrates.

Table 3-2
KESTERSON RESERVOIR
1989 INVERTEBRATE SELENIUM CONCENTRATIONS
(ppm dry weight)

	N	GEOMETRIC MEAN	RANGE
GRASSLAND			
grasshoppers	22	4.2	2.0 - 16
beetles	27	13	1.9 - 78
crickets	22	6.9	1.0 - 21
sowbugs	25	58	23 - 87
mixed aerials	30	6.4	2.0 - 18
spiders	19	11	2.0 - 40
FILLED			
grasshoppers	15	3.1	0.7 - 9.6
beetles	13	8.1	0.1 - 26
crickets	4	4.8	3.5 - 6.7
sowbugs	1	32	
mixed aerials	21	3.8	2.0 - 8.3
spiders	11	9.9	2.0 - 30
OPEN			
grasshoppers	18	6.4	2.0 - 25
beetles	19	17	8.3 - 41
crickets	15	13	6.3 - 23
sowbugs	7	61	32 - 120
mixed aerials	22	5.8	2.8 - 18
spiders	15	14	3.0 - 84

There were significant differences of selenium levels between species of invertebrates at Kesterson Reservoir. In general, predatory invertebrates and invertebrates that live and forage on the ground had higher selenium concentrations than those that live and forage in the tops of plants.

When invertebrates from different trisections were compared, the overall geometric mean selenium level showed a trend of decreasing selenium from south to north but the differences were not significant. Trisection 1 invertebrates generally had higher selenium levels than invertebrates from either Trisection 2 or 3. Grasshopper selenium levels were almost the same in all three trisections. Spiders had higher selenium levels in Trisection 3 than Trisection 2; although the difference was not significant, it was the same pattern found in sowbugs.

Usually, there were few significant differences between samples collected from different habitats comparing the same species. Exceptions to this were crickets in Trisection 1; significantly higher levels of selenium were found in samples collected from the open habitats than from either the grassland or filled habitats. Significantly higher levels of selenium were found in mixed aerial insects (sweep net samples comprised of flies, butterflies, bees, bugs, and other invertebrates) collected from Trisection 1 grassland areas than in samples from filled habitats, and mixed aerial insects collected from Trisection 3 open habitats were significantly higher in selenium than those collected from filled habitats in that trisection.

No significant seasonal differences were found between invertebrate samples collected in Kesterson Reservoir during the 1989 sampling period.

SOIL

The geometric mean selenium level in the water extractable fraction of soil collected from all three habitat types at Kesterson Reservoir showed a trend of decreasing selenium levels from south to north (Table 3-3). However, the differences were not statistically different between trisections, and no consistent relationship was found between the level of soluble selenium in soil in the different habitats and the level of selenium found in particular plants. There were usually no significant differences between habitat soluble selenium levels within trisections, but there were significant differences between open habitat soluble selenium samples and both grassland and filled samples when samples from all three trisections were combined.

Table 3-3
KESTERSON RESERVOIR
1989 WATER EXTRACTABLE SELENIUM CONCENTRATIONS IN SOIL
(ppm per solid mass)

	N	GEOMETRIC MEAN	RANGE
GRASSLAND	18	0.045	0.01 - 0.26
FILLED	18	0.014	0.001 - 0.43
OPEN	18	0.068	0.01 - 0.37

RAINWATER PUDDLES

Numerous shallow rainwater puddles formed on top of filled habitat after heavy rainfall during the winter of 1988-1989. These puddles formed where there were slight topographic depressions and/or where soils were heavily compacted by equipment during the filling operation. Puddles were estimated to cover about 1 percent of filled habitat after a heavy rainfall at Kesterson Reservoir. No significant puddling was observed in either the open or grassland habitats at the Reservoir. Within in a matter of a few days following a heavy rainfall, many surface puddles disappeared. However, in some areas puddles persisted for weeks, usually overlapping subsequent heavy rainfall. The largest of these persistent puddles was located in Trisection 1 and varied between about 0.25 and 0.35 acre in size. In total, these persistent puddles encompassed a total of about 3 acres, or about 0.25 percent of the entire Kesterson Reservoir area.

Reservoir-wide, the geometric mean selenium concentrations in rain puddles was 4.0 ppb (n=53; range=<1-50). A general trend of decreasing selenium concentration from south to north was observed. This trend is similar to trends observed in the water extractable fraction of soil selenium. The highest concentrations were found in puddles in Trisection 1. In late February, aquatic invertebrates were discovered in a group of puddles in Trisection 1. No vegetation was observed in these puddles, but widgeongrass seeds and signs of wildlife activity were observed around their edges. Seeds and aquatic beetles were collected for selenium analysis. Widgeongrass seeds had a geometric mean selenium concentration of 622 ppm (n=3; range=570-680). The aquatic beetles had a geometric mean selenium concentration of 15.3 ppm (n=5; range=13-19) which is comparable to levels found in terrestrial beetles collected during the 1989 sampling year.

DISCUSSION

VEGETATION

Selenium levels in vegetation samples collected at Kesterson Reservoir did not vary greatly throughout the year. No significant differences were observed within individual species collected in different seasons from the same habitats. It is possible that the fraction of selenium available in the soil for plants does not change from season to season but may change over a longer period of time such as from year to year.

Salt grass samples were the only vegetation sampled that showed a difference within species between trisections. Salt grass samples from grassland habitat in Trisection 1 (geometric mean=4.2 ppm) were significantly higher than salt grass

samples collected from grassland habitat in Trisection 3 (geometric mean=2.0 ppm). When all plant samples collected during this monitoring year were combined from each trisection, a general trend of decreasing selenium concentration from south to north was observed in the grassland and open habitats, but the difference between trisections was usually not statistically significant. This declining trend from south to north may be related to the trend of selenium levels found in soil samples, although the constant fraction of total soil selenium is not necessarily available for plant uptake.

Mustard collected from filled habitat in the spring sampling period had a geometric mean selenium level of 13.6 ppm (n=18; range=2.9-82 ppm) suggesting that mustard may accumulate selenium in its vegetative parts (Benson, personal communication). Mustard was not widespread in the Reservoir and was not found to be a major food item of any of the birds or mammals collected at Kesterson Reservoir.

INVERTEBRATES

Comparisons between individuals collected in different sample periods or different habitats may not be valid because of the great variations between individuals within orders, the ability of individuals to move between habitats, and the variety of selenium levels in food items taken by individuals. Invertebrates employ a variety of feeding strategies (i.e., herbivorous, carnivorous, omnivorous, and detritivorous) that can include vegetation and soil litter, as well as other invertebrates. This may account for the wide range of selenium levels found in the invertebrates collected. Selenium levels in invertebrates may reflect the levels found in food items. For example, grasshoppers are herbivorous and forage on living vegetation. They had a geometric mean selenium concentration of 4.4 ppm which was the lowest geometric mean selenium concentration of the invertebrate samples collected. Mixed aerial insect samples consisted of a variety of species of flies, bees, bugs, and beetles that forage primarily on the tops of plants or prey on other invertebrates that forage in the tops of vegetation. This variety of invertebrates may be similar to what an aerial insectivore such as a barn swallow would eat. Geometric mean selenium levels for mixed aerial insects was 5.3 ppm. Crickets and beetles use feeding strategies that can include vegetation, detritus, and other invertebrates. This may account for the generally higher selenium levels and the wide range of selenium levels found in both crickets and beetles than that found in organisms such as grasshoppers.

Predatory invertebrates, such as spiders had selenium concentrations that reflected the ranges found in their prey which include most of the invertebrates found at Kesterson Reservoir, possibly even sowbugs. Sowbug exoskeletons have been found in webs, and geometric mean selenium concentrations of both sowbugs and spiders were higher (not significantly) in Trisection 3 (57.7 and 9.4 ppm

respectively) than in Trisection 2 (44.3 and 8.5 ppm) contrary to the general trend of decreasing selenium levels from south to north. This suggests a possible relationship between these two orders, but it is certainly not conclusive evidence.

High selenium levels in sowbugs may be related to the high selenium levels concentrated in the detritus where sowbugs live and forage. The detritus layer consists of organic and inorganic sediments mixed with dead or decaying plant material. Some of these materials remain from when the Reservoir was flooded with drainwater in the past. Soil litter geometric mean selenium levels have ranged from 25 to 166 ppm in the past. Sowbugs have not been found in any of the digestive tracts of birds or mammals examined to date.

SOIL

Generalizations can be made to trends in total soluble selenium in soil and similar trends found in plant selenium concentrations, but a direct relationship could not be made, so these trends should be interpreted with caution.

SURFICIAL WATER

Widgeongrass seed and aquatic beetles were found in only one area of Trisection 1. No green vegetation was observed in these puddles when the samples were collected, and the puddles dried up before widgeongrass or other vegetation appeared. These areas have since been managed by filling and deep ripping to prevent puddles from forming again.

Chapter 4
BIRD CENSUSING

OBJECTIVES

The purpose of the bird census was to identify the species of birds that use Kesterson Reservoir throughout the year, estimate their populations, and document changes in species composition over time.

METHODS

Two bird census techniques were employed at Kesterson Reservoir to estimate populations of bird species at Kesterson Reservoir. Monthly average populations were estimated from daily bird counts, and a bi-monthly bird census was used to estimate monthly populations of upland bird species.

Monthly average population estimates were made for species such as shorebirds, swallows, blackbirds, and raptors by recording the number and species of birds observed on the Reservoir while driving around and through the site. The survey is performed at different times of the day during each month. At the end of each month, the number of individuals of each species of bird are divided by the number of days during the month that surveys were performed to calculate monthly population averages. Although it is not a true census, this technique has been used at Kesterson Reservoir in the past by both USFWS and USBR to keep track of bird use.

Population estimates of upland birds such as western meadowlarks, horned larks, water pipits, and sparrows were made by walking premarked transect belts. This was done at least twice every month when weather permitted. Fixed transect belts were used to decrease variability by the observer and to delineate the habitats. The belts were marked inside each pond with stakes and flagging. Transect belts were cut into 50-meter-long by 122-foot-wide intervals. All birds seen or heard within the transect belts were counted, identified, and recorded on preformatted data sheets including the following data: date, time census run begins and ends, transect identification, interval identification (type of habitat), species observed, and the number of individuals of each species heard or seen. The strip censuses commenced at sunrise, and observations ended within about 3.5 hours after sunrise. Density was calculated by: $D=n/ZLW$ (D=density; n=number of observations; L=transect (interval) length; W=transect width) (Emlen 1971). Relative abundance was calculated by using the proportion of total birds of each species compared to the number of all birds of all species

observed (Call 1982; Dawson 1981). The monthly population estimate was calculated by multiplying the estimated density per acre of the species in the transect by the acres of the habitat type used by the species in the transect's corresponding trisection.

RESULTS

The results of the bird census at Kesterson Reservoir for 1989 are summarized in Table 4-1. A list of all birds that were observed at Kesterson Reservoir in 1989 is presented in Appendix A-2.

Most duck, coot, stilt, and avocet foraging and nesting habitat have been eliminated from Kesterson Reservoir. These species were only occasionally observed on the Reservoir. Most sightings were in areas of the Reservoir where the San Luis Drain or Mud Slough run along the edge of the Reservoir. Since filling, killdeer use of the Reservoir has decreased and snowy plovers were only sighted during the nesting season. Numbers of snowy plovers observed on the Reservoir, as in the past, are low.

During the winter months, large numbers of water pipits, horned larks, and sparrows (mostly savannah, grasshopper, and white-crowned sparrows) were observed on the Reservoir. Water pipits foraged in the unvegetated newly filled areas, mostly in Trisection 1. Horned larks foraged in filled areas with sparse vegetation, primarily in Trisection 2 and 3. Sparrows were observed throughout the Reservoir in grassland and filled habitats foraging for seeds and invertebrates.

The water pipits did not nest on Kesterson Reservoir and were not observed at the Reservoir after February. Horned larks and sparrows were observed in large numbers at the Reservoir through April. After April, the numbers of these birds decreased dramatically; only a few were sighted through the summer months to August. Horned lark numbers were highest during their nesting season at Kesterson Reservoir (February and March). Sparrows were not observed nesting at Kesterson Reservoir and apparently only forage at Kesterson Reservoir through the non-reproductive season; their numbers began to increase again in September.

Western meadowlarks were observed primarily in grassland habitat but began to utilize the filled areas to forage for invertebrates and seeds after these areas became vegetated. The number of western meadowlarks observed on the Reservoir increased through the nesting and fledging period, from February through June, and decreased from July.

Both blackbirds (mostly Brewer's blackbirds) and house finches foraged primarily in filled habitats for seeds and invertebrates, through the late spring and early

Table 4-1
KESTERSON RESERVOIR
1989 BIRD POPULATIONS
(average population)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Sparrows	182	373	272	193	0	21	4	3	120
Western meadowlark	27	138	178	226	208	237	98	77	48
Horned lark	310	500	808	353	56	63	36	34	13
Water pipit	116	11	0	0	0	0	0	0	0
House finch	0	0	0	8	37	115	193	20	9
Blackbirds*	13	7	6	110	320	135	8	0	3
Raptors*	9	11	7	5	4	5	7	9	12
Ducks*	0	1	1	4	7	3	1	0	0
Killdeer*	1	3	4	11	9	8	2	3	7
Swallows*	--	--	--	45	68	70	42	39	11
Coots*	1	1	1	0	1	0	0	1	0

*- From USBR daily bird counts.
-- Swallows were not counted prior to April 1989.

summer months. Blackbirds were not observed nesting on the Reservoir, but house finch nests were found on structures in the Reservoir, such as gates, and on structures on the periphery of the Reservoir. Although they were observed foraging in the Reservoir alongside other blackbirds, tricolor blackbirds, which nested at Kesterson Reservoir in the past, did not nest at the Reservoir in 1989.

Raptors were observed foraging throughout the Reservoir for small mammals, birds, and reptiles. Numbers of raptors using Kesterson Reservoir were similar to the numbers observed prior to filling; they are not expected to change radically in the future.

DISCUSSION

The open areas were rarely used by birds at Kesterson Reservoir during the 1989 censuses. Use of these areas is expected to increase as more vegetation begins to grow in the open areas. The filled areas were used by most of the species observed at Kesterson Reservoir at some time of the year for foraging. Water pipits were only observed in the filled areas before they were covered with vegetation. The lack of filled areas with sparse or no vegetation may reduce or eliminate water pipits and, to a lesser extent, horned larks from Kesterson Reservoir in the future. Blackbirds, sparrows, and house finches were observed foraging primarily in the filled areas where there was an abundance of annual grass and perennial seeds as well as a variety of invertebrates. These species as well as other terrestrial birds should continue to utilize this resource. Western meadowlarks primarily used the grassland areas for foraging until after the nesting season when they began to disperse and were observed in both grassland and filled areas.

Occasional waterfowl and shorebirds will continue to be observed at Kesterson Reservoir because of the proximity of the Reservoir to the duck clubs of the nearby Grassland Water District, Kesterson National Wildlife Refuge, the San Luis Drain, and Mud Slough. Some waterfowl will continue nesting attempts on upland areas inside the Reservoir near the wetland areas surrounding Kesterson Reservoir. There are minimal foraging areas in the Reservoir for waterfowl, and, therefore, minimal opportunities for waterfowl to be exposed to the selenium inventory on the Reservoir. Rainwater puddles are not expected to last long enough at Kesterson Reservoir in 1990 to be attractive to waterfowl or shorebirds for foraging, due to management actions taken in 1989.

Killdeer and snowy plovers are the only shorebirds that have been observed nesting on the Reservoir; this situation is expected to continue, although in decreasing numbers. Pheasants have been observed at the Reservoir in the past, but no nesting has been observed. The grassland and open habitats at

Kesterson Reservoir are not suitable nesting habitat for these birds; they require open areas with soil or gravel in which they can make a depression for the eggs. The filled areas have also become poor nesting habitat for these birds in most areas of the Reservoir because of the thick vegetation that has grown in most areas.

Chapter 5
BIRD NESTING SURVEY

OBJECTIVES

The objective of the spring nesting survey was to assess the reproductive success of terrestrial birds at Kesterson Reservoir by determining the frequencies of embryonic mortalities, developmental abnormalities, hatching success of birds, and fledging success during the 1989 nesting season at Kesterson Reservoir.

METHODS

NEST SEARCHES

From mid-March until the end of June 1989, bird nests were searched for and nests were monitored at Kesterson Reservoir. Western meadowlark nests were located by observing activities of birds in nesting habitats. When active territories were found, nests were pinpointed by dragging a chain through the grass in those areas. This method has been used successfully at Kesterson Reservoir for locating western meadowlark nests and has been used by USFWS personnel in the past to locate waterfowl nests (Ohlendorf, personal communication). This method is a modification of the method described by Higgins et al. (Higgins et al. 1977; Higgins et al. 1969; Klett et al. 1986). Waterfowl nests were searched for in areas where they were observed flying to at dusk or flying out of at dawn.

The levee roads were searched for killdeer and lesser nighthawk nests. These birds are usually visible from the roads surrounding the ponds. Nests were keyed in on by driving slowly along the levee roads and watching for the adult leaving the nest, displaying, or sneaking. When the birds were located, one biologist sighted the nest and directed the second biologist to its location. Barn swallow nests were located by searching the culverts that remained at Kesterson Reservoir south of Gun Club Road and searching beneath other structures on the Reservoir. Other nests were located opportunistically.

NEST MONITORING

After a nest was found, it was marked with flagging (approximately 10 feet away from the nest), mapped, and given a unique code. Nest codes included four-letter species acronyms, the pond or culvert number, and a nest (or a clutch) number. For example, Stne 9-1 indicated the first western meadowlark nest found at Pond 9; Chvo 3-3 indicated the third killdeer nest found in Pond 3; and Hiru 1-2 indicated the second barn swallow clutch found in the nest in the western-most

culvert south of Gun Club Road in Pond 4 of the Reservoir. Monitoring of the nest began immediately after it was marked and continued on a weekly basis to assess hatching success, nestling survival, and fledging success. Every effort was made to minimize disturbance of the nesting birds.

EGG COLLECTIONS

One egg was removed immediately after a nest was located. The egg was candled using a modified flashlight to determine the condition of the embryo (alive or dead) and to estimate the stage of embryonic development. At the time of collection, each egg was marked with its nest code and the date it was removed. This was recorded on a data sheet and the egg was placed into a container to avoid damage. All eggs removed from nests were examined or refrigerated within 1 hour of collection. The eggs remained refrigerated until they were examined. If the condition of the embryo could not be determined by candling, the egg was examined within 1 to 2 days of collection. The contents of the egg were then saved for residue analysis.

LABORATORY EXAMINATIONS

All eggs collected were examined as soon after collection as possible. Each egg was opened to determine fertility, stage of development, the position of the embryo, and whether pipping (internal pipping into the air cell or external pipping of the shell) had occurred. Each embryo was also examined for evidence of external deformities and other abnormalities. The entire egg contents were then saved in chemically cleaned containers and kept frozen until they were shipped to the laboratory for selenium analysis.

RESULTS

A comparison of selenium concentrations in eggs collected from Kesterson Reservoir is presented in Table 5-1.

Nests of killdeer, barn swallows, mourning doves, mallard, and western meadowlarks were found during the 1989 reproductive season at Kesterson Reservoir. The results of the 1989 bird nesting survey are presented in Table 5-2.

KILLDEER

Few killdeer used the Reservoir for nesting or foraging in 1989. Over the 3 months of highest killdeer reproductive activity in the area (April, May, and June), the population on the Reservoir averaged nine birds. Eight eggs were

Table 5-1
SUMMARY OF EGG SELENIUM CONCENTRATION
(ppm dry weight)

SPECIES	YEAR	N*	GEOMETRIC MEAN	RANGE
Mallard	1988	5	11	3.9 - 31
Mallard	1989	1	3.7	3.7
Gadwall	1988	2	5.4	3.5 - 8.4
Killdeer	1988	15	19	7.6 - 58
Killdeer	1989	6	6.6	4.2 - 15
Barn swallow	1988	23	6.9	3.8 - 11
Barn swallow	1989	13	5.6	4.0 - 7.9
Mourning dove	1988	1	1.7	1.7
Mourning dove	1989	2	2.5	1.3 - 4.7
Meadowlark	1988	2	23	22 - 24
Meadowlark	1989	5	10	4.8 - 17

* - One egg with the highest selenium concentration in the clutch selected from each nest.

Table 5-2

RESULTS OF EXAMINATIONS OF EGGS COLLECTED AT KESTERSON RESERVOIR 1989

Species	Pond - Nest/Egg Number	Egg Collection Date	Clutch Size	Embryo Condition*	Embryo Stage**	Normal (N) Abnormal (A)	Se (ppm)
Western meadowlark	9- 1a	28-Apr	5	+	36+	N	17
Western meadowlark	10- 1b	16-May	5	A	3	--	4.4
Western meadowlark	10- 1c	19-May	5	A	3	--	4.3
Western meadowlark	10- 1d	19-May	5	A	3	--	4.8
Western meadowlark	10- 1e	19-May	5	A	3	--	3.9
Western meadowlark	11- 1a	5-Apr	5	+	35	N	7.8
Western meadowlark	11- 1b	7-Apr	5	A	35	N	7.5
Western meadowlark	11- 1c	7-Apr	5	A	35	N	7.6
Western meadowlark	11- 1d	7-Apr	5	A	35	N	7.1
Western meadowlark	12- 1a	12-Mar	5	+	30	N	13
Western meadowlark	12- 2a	6-Apr	5	+	36	N	11
Western meadowlark	12- 2b	14-Apr	5	A	39	N	12
Western meadowlark	12- 2c	14-Apr	5	A	39	N	13
Western meadowlark	12- 2d	14-Apr	5	A	39	N	12
Western meadowlark	12- 2e	14-Apr	5	A	39	N	14
Killdeer	2- 1a	14-Jun	4	+	25	N	15

ND - No visible embryonic development.

* - (+) indicates embryo was alive when collected; (-) indicates embryo dead when collected;
(A) indicates embryo condition unknown- from an abandoned nest; (B) nest accidentallycrushed; (F) Fertile egg.

**- Chickstage (Hamilton 1952) used for physical description of the embryo.

Table 5-2

RESULTS OF EXAMINATIONS OF EGGS COLLECTED AT KESTERSON RESERVOIR 1989

Species	Pond - Nest/Egg Number	Egg Collection Date	Clutch Size	Embryo Condition*	Embryo Stage**	Normal (N) Abnormal (A)	Se (ppm)
Killdeer	3- 3a	9-May	4	+	33-	N	4.2
Killdeer	4- 1a	9-May	3	+	32+	N	5.7
Killdeer	4- 2b	10-May	4	B	38	N	6.2
Killdeer	4- 2c	10-May	4	B	38	N	4.2
Killdeer	4- 2d	10-May	4	B	38	N	3.5
Killdeer	3- 2a	8-Apr	4	+	14	N	4.9
Killdeer	11- 1a	14-Apr	4	+	40	N	7.5
Barn swallow	1- 1c	20-Apr	4	F	ND	N	5.1
Barn swallow	1- 2a	16-May	5	F	ND	N	4.8
Barn swallow	1- 3a	16-Jun	5	+	33	N	5.2
Barn swallow	2- 1a	27-Apr	4	+	35	N	5.8
Barn swallow	2- 2a	4-Jun	4	F	ND	N	5.4
Barn swallow	3- 1a	5-May	4	+	20	N	4.2
Barn swallow	3- 2a	27-Jun	4	+	37	N	6.6
Barn swallow	4- 1a	7-Apr	1	F	ND	--	6.7
Barn swallow	4- 2a	5-May	5	+	28+	N	5.8
Barn swallow	4- 3a	4-Jun	5	F	ND	N	7.9
Barn swallow	5- 2a	16-Jun	4	+	30	N	7.6
Barn swallow	7- 1a	16-May	5	+	21	N	5.0

ND - No visible embryonic development.

* - (+) indicates embryo was alive when collected; (-) indicates embryo dead when collected;
(A) indicates embryo condition unknown- from an abandoned nest; (B) nest accidentallycrushed; (F) Fertile egg.

**- Chickstage (Hamilton 1952) used for physicaldescription of the embryo.

Table 5-2

RESULTS OF EXAMINATIONS OF EGGS COLLECTED AT KESTERSON RESERVOIR 1989

Species	Pond - Nest/Egg Number	Egg Collection Date	Clutch Size	Embryo Condition*	Embryo Stage**	Normal (N) Abnormal (A)	Se (ppm)
Barn swallow	7- 2a	27-Jun	4	F	ND	N	4.0
Mourning dove	5- 1a	1-May	2	+	32	N	4.7
Mourning dove	7- 1a	5-Apr	2	+	17	N	1.3
Mallard	4- 1a	19-May	8	+	38	N	3.7

ND - No visible embryonic development.

* - (+) indicates embryo was alive when collected; (-) indicates embryo dead when collected;
(A) indicates embryo condition unknown- from an abandoned nest; (B) nest accidentallycrushed; (F) Fertile egg.

**- Chickstage (Hamilton 1952) used for physical description of the embryo.

collected out of six nests from April through June; all the eggs collected contained normal, living embryos. The geometric mean selenium concentration in killdeer eggs collected in 1989 was 5.8 ppm (range=3.5-15.2). Nest predation occurred at one nest before an egg was collected, and one nest (killdeer 4-2) was stepped on and all eggs were collected. No embryonic deformities or other embryo mortality was observed in killdeer nests monitored during the 1989 reproductive season. All remaining killdeer nests monitored successfully fledged young.

BARN SWALLOW

Barn swallows nested in the remaining culverts south of Gun Club Road and below the weather structure at the south tip of pond 1. One nest (barn swallow 4-1) was destroyed when it fell off the wall of the culvert. Twelve other nests were monitored through the nesting season with no observed mortality. Thirteen barn swallow eggs were collected with a geometric mean selenium concentration of 5.6 ppm (n=13; range=4-7.9). No embryo abnormalities or mortality was observed in barn swallow nests during the 1989 reproductive season. All nests, except the one nest destroyed, successfully fledged young.

MOURNING DOVE

Two mourning dove nests were found, and an egg was collected from each nest. Both nests were on the ground and successfully fledged young. The geometric mean selenium concentration of the two eggs was 2.5 ppm (n=2; range=1.3-4.7). Both embryos were alive and embryo abnormalities were not observed.

MALLARD

A single mallard nest was found in Trisection 1 in 1989. The selenium level in the egg was 3.7 ppm and the embryo in the egg was alive with no gross abnormalities. The mallard successfully hatched the clutch and fledged the young from the nest successfully.

WESTERN MEADOWLARK

Fifteen eggs were collected from five nests between February and June 1989 (the western meadowlark nesting season). A comparison of selenium concentrations in eggs collected from Kesterson Reservoir is presented in Table 5-2. Of the five nests found, three nests were abandoned after discovery, possible snake predation occurred at one nest, and the other nest was successful. All of the nests contained five eggs when they were found and all the eggs that remained in nests after they were determined to be abandoned were collected. The geometric mean selenium concentration for western meadowlark eggs (using the egg

with the highest selenium level from each nest) was 10 ppm (n=5; range=4.8-17). All the eggs collected from the nest when they were discovered were living and no abnormal embryos or embryo mortality was found in western meadowlarks. Two nests were found with chicks already hatched (Trisection 1 and Trisection 3); the chicks successfully fledged from the nests.

DISCUSSION

The number and types of nests found at Kesterson Reservoir in 1989 reflected the populations and species of birds observed at the Reservoir during the spring sampling period. Of the nests found, only western meadowlark nest numbers were fewer than expected, based on the large number of meadowlarks on the Reservoir during the nesting season. However, it is possible that we found a large fraction of the total meadowlark nests at Kesterson Reservoir in 1989 based on the amount of suitable territory meadowlarks require for nesting and the high nest predation rate expected. The total meadowlark population averaged 197 birds, and the estimated total of nesting habitat (grassland habitat) at Kesterson Reservoir was 396 acres. Lanyon (1957) estimated that meadowlark nesting territories ranged from 3 to 15 acres and were most commonly 7 to 8 acres in his 100-acre study plot. Unlike Lanyon's study plot, which was a homogenous grassland habitat, Kesterson Reservoir habitats were a mosaic of grassland, open, and filled habitats. Another study of reproduction in passerine birds (Rotenberry and Weins 1989) showed that nest predation, especially by gopher snakes, plays a major role in reproductive success. In three study sites over a 2-year period: two sites with gopher snakes present had nest predation rates of 40 percent and 93 percent while the other sites where gopher snakes were not present had virtually no nest predation. Using 7 acres as the average nesting territory and 40 percent as the predation rate, there would have been about 23 possible successful nests at Kesterson Reservoir, of which 5 nests with eggs and 2 with chicks (30 percent of expected nests) were found. Also, a meadowlark with nesting territory partially in the Reservoir may have a nest outside of Kesterson Reservoir.

Overall, nesting at Kesterson Reservoir was successful in 1989. Selenium concentrations were lower in eggs collected in 1989 when compared to eggs collected from the same species in 1988, but not significantly. The selenium levels found in some eggs are high enough that there continues to be a possibility of impact on embryos, although no embryo abnormalities or unusual embryo mortalities were observed in either year. Toxic effects of selenium have not been observed in terrestrial birds at Kesterson Reservoir; this may be due to differences in the food chain now available to birds at Kesterson or possibly to some difference in the types of species of birds now inhabiting the Reservoir that is as yet unknown.

Chapter 6
BIRD COLLECTIONS AND ANALYSIS FOR CONTAMINANTS

OBJECTIVES

Western meadowlarks were collected to determine their feeding habits and the selenium concentration in their livers. Other birds found dead and salvaged were necropsied and their livers analyzed for selenium concentration. This information was compared to information obtained in other years to document the trends and effects of selenium on the terrestrial birds at Kesterson Reservoir.

METHODS

TRAPPING METHODOLOGY

Western meadowlarks, insectivorous birds present at Kesterson Reservoir year round, were collected during the first week of June 1989 with a shotgun. Birds were collected before they began to disperse at the end of their nesting season at Kesterson Reservoir. This collection time was chosen to minimize disruption of nesting birds and still obtain resident birds that had foraged primarily on the Reservoir. Four meadowlarks were collected from Trisection 1, three birds were collected from Trisection 2, and three from Trisection 3. Birds found dead on the Reservoir were also collected.

SAMPLE PREPARATION

Salvaged birds were frozen and later necropsied to diagnose the cause of death. The crop and gizzard contents were also examined to determine feeding habits of the birds. Each collected bird was weighed and necropsied to determine its overall condition and to note any gross abnormalities. The reproductive condition of each bird was noted, the left testis was measured, and the crop and gizzard contents were removed for identification. The liver was removed from each animal, weighed and placed in a labeled, chemically cleaned container, and frozen. Livers were sent frozen to Environmental Trace Substance Research Center (ETSRC) for selenium analysis.

RESULTS

The geometric mean selenium level in livers of western meadowlarks collected from Kesterson Reservoir in 1989 was 16 ppm (n=10; range=4.8-36). All meadowlarks collected appeared to be in good condition as determined by necropsy.

Western meadowlarks' stomach contents consisted mainly of crickets, beetles, grasshoppers, bees, ants, beetle larvae, and grass seed. No sowbugs were found in any meadowlark's digestive tract. The results of the food habits analysis for birds is presented in Table 6-1.

DISCUSSION

Taken together, the geometric mean selenium level in meadowlarks collected in 1989 was lower than the geometric mean of birds collected in 1988 (1989 GM=16 ppm; 1988 GM=22.6 ppm; n=15; range=8.4-76), although the difference in selenium levels was not statistically different.

The types of food items observed in meadowlark digestive tracts from Kesterson Reservoir were consistent with food items found in meadowlarks collected in 1988 from Kesterson Reservoir, and the results were also consistent with other studies of meadowlark food habits (Rotenberry 1980; Knowlton 1943; Bent 1965). The food items reflect the opportunistic feeding habits employed by meadowlarks, and the wide range of meadowlark liver selenium values reflect the range of selenium levels found in their food items.

All the meadowlarks collected appeared healthy, determined by the amount of fat and muscle and the healthy appearance of the integument and internal organs, and no abnormalities were found. Although the levels of selenium found in western meadowlarks collected at Kesterson Reservoir were elevated in 1989, toxic effects were not observed.

Table 6-1
KESTERSON RESERVOIR
1989 WESTERN MEADOWLARK FOOD HABITS*
AND SELENIUM CONCENTRATION
(ppm dry weight)

Trisection	Grasshoppers	Crickets	Beetles	Beetle larvae	Bees & ants	Feathers /Grit	Bugs	Grass Seeds	Seeds	Vegetation	Liver Selenium Concentration (ppm)
1	2.5	90	2.5			5					36
1		90						10			29
1		95							5		13
1		55		5			40				24
2	20	48	3			3		28			16
2	25				5	8		45	3	15	14
2		18	15	30	30					10	18
3		90				10					4.8
3		55	33		13						12
3	23	23	55								15

* - Percent relative density.

Chapter 7
REPTILE/AMPHIBIAN COLLECTIONS AND ANALYSIS FOR CONTAMINANTS

OBJECTIVES

The objective of this survey was to document the levels and impacts of selenium in the common reptiles and amphibians found at Kesterson Reservoir. Reptiles and amphibians are a part of the prey base for carnivorous mammals and predatory birds that forage at Kesterson Reservoir.

METHODS

TRAPPING METHODOLOGY

Reptiles and amphibians were to be collected opportunistically throughout the year, depending on their availability, at Kesterson Reservoir. The target species we expected to collect were: side-blotched lizard (Uta stansburiana), western fence lizard (Sceloporus occidentalis), gopher snake (Pituophis melanoleucus), and western toad (Bufo boreas). When captured, representative samples of less common species such as the common kingsnake (Lampropeltis getulus) were to be sampled. A maximum of 10 individuals of each target species from throughout the Reservoir were to be collected.

To enhance collecting success and repeatability of collections from saltgrass areas, 4-foot by 4-foot sheets of plywood were placed in three saltgrass areas within each pond. Pitfall or can traps were also set up for sampling. A combination of opportunistic and systematic collecting methods such as, road riding, pitfall or can trapping, and hand catching were used. Active searches for reptiles and amphibians were made by turning over rocks, boards, and other debris.

SAMPLE PREPARATION

The liver from each animal was removed and analyzed separately from the remainder of the carcass for selenium. The liver was weighed and placed in a labeled, chemically cleaned container. Total body (head-tail) measurements and weight were recorded, and reproductive condition was determined. Each carcass was weighed and placed in a separate labeled, chemically cleaned container.

RESULTS

Six gopher snakes were collected and killed by freezing. The results of selenium analysis of snakes are presented in Appendix B-3. The geometric mean selenium level in gopher snake livers from Kesterson Reservoir was 7.1 ppm (n=6; range=1.7-31.4). The geometric mean selenium concentration in the whole bodies of gopher snakes was 4.6 ppm (n=6; range=0.7-35).

All the snakes appeared to be in good condition, based on the amount of fat and muscle present, and the healthy appearance of the integument and internal organs. Two of the males were in reproductive condition (determined by testis measurements), and one female snake was in reproductive condition (determined by enlargements of the follicles and changes in the reproductive system).

DISCUSSION

Gopher snakes were the only reptile that was abundant at Kesterson Reservoir in 1989. No amphibians and very few side-blotched lizards were observed on the Reservoir. Gopher snakes at Kesterson Reservoir had a large range of selenium levels, possibly a reflection of the wide range of selenium levels in their prey (primarily birds, bird eggs, and small mammals (Call 1982; Stebbins 1966)). The geometric mean selenium level in gopher snake livers (7.1 ppm) collected in 1989 was lower than the geometric mean selenium concentrations reported by Ohlendorf et al. (1988) in gopher snakes collected in 1984 and 1985 (11.1 ppm).

No adverse affects in gopher snakes were reported by Ohlendorf et al. (1988) and none were observed in snakes collected in 1989 from Kesterson Reservoir, although the level of selenium in most of the snakes collected was elevated above the levels for snakes from uncontaminated sites. There is a possibility that high selenium levels found in some of the snakes collected could possibly threaten predatory birds and mammals that feed on them.

Chapter 8
SMALL MAMMAL COLLECTIONS AND ANALYSIS FOR CONTAMINANTS

OBJECTIVES

The objectives of this survey were to document the levels of selenium in small mammals at Kesterson Reservoir and to demonstrate the route of selenium accumulation in small mammals by determining food habits. Small mammals are the major prey base for higher trophic-level birds, reptiles, and mammals including the endangered San Joaquin kit fox.

METHODS

TRAPPING METHODOLOGY

Small mammals were trapped from each trisection. Nine trap-line locations were selected along the bird census transects in each trisection. Trapping and bird censusing were timed not to overlap; setting and collecting traps was not done during censuses. Museum Special snap-traps were baited with peanut butter and placed at 10-meter intervals along each transect line for trapping deer mice, ornate shrews, and western harvest mice. California voles do not deviate from their runways and are not attracted to baits, so Museum Special snap-traps were placed on runways and around bushes where vole sign was found adjacent to the trap-lines. Valley pocket gophers were collected from each trisection using kill traps set in active tunnels.

SAMPLE PREPARATION

From each trisection, one individual of each collected target species was selected from each of nine trap-lines for laboratory analysis to determine selenium content. An individual was randomly selected for selenium analysis if more than one individual of a target species was trapped per transect.

Each animal's liver and carcass was analyzed separately for selenium. Each liver was removed, weighed, and placed in a labeled, chemically cleaned sample container. The stomach was severed from the digestive tract at the esophageal and pyloric sphincters. Stomachs were opened lengthwise beginning at the pylorus, and the contents were removed to prevent contamination by selenium in the stomach contents and for identification of food items. Each empty stomach was then placed with the respective animal in chemically cleaned containers. All samples were weighed, labeled, and refrozen.

The stomach contents of animals collected were examined to estimate their diet by microscopically identifying plant and invertebrate fragments. Rodents chew vegetation very finely, making identification by gross examination impractical; a staining procedure was used for identifying plant material. Material from the stomachs of animals collected was stained and matched against the reference set of vegetation standards for identification (Westoby et al. 1976; Williams 1962). Microscopic food habit analyses were performed at the Composition Analyses Laboratory, Colorado State University. Reproductive status was determined by testes size and location, uterine measurements, implantation scars, corpora lutea, and follicle counts, as well as by the presence or absence of embryos, and embryo size (Christian 1950; Conaway 1955). All animals were sexed and weighed. Total body (head-tail), tail, right hind foot and right ear lengths were measured and recorded.

RESULTS

TRAPPING

Relative abundance of the species trapped in 1989 was qualitatively determined by numbers of animals found in traps and the amount of sign found for each species. Deer mice were abundant throughout the Reservoir and easily trapped in all trisections. California voles were abundant in Trisections 1 and 2, but were difficult to find in Trisection 3. Western harvest mice and pocket gophers were easily collected from Trisections 2 and 3 and difficult to collect in Trisection 1. Though not very abundant, ornate shrews and house mice were present throughout the Reservoir. The frequency with which small mammals were collected in the three trisections is presented in Table 8-1.

REPRODUCTION

The results of examinations for reproductive condition of 123 adult small mammals are presented in Table 8-2. Out of the 123 animals (74 males and 49 females), 61 males and 29 females (82 and 59 percent, respectively) were in reproductive condition. March and April were the months of highest reproductive activity in the Kesterson Reservoir mammals. One female vole with a normal internal reproductive system was found lacking an opening in the integument for the vagina. No other reproductive abnormalities were observed in small mammals from Kesterson Reservoir.

Table 8-1
KESTERSON RESERVOIR
FREQUENCY OF SMALL MAMMALS COLLECTED

SPECIES	Trisection 1	Trisection 2	Trisection 3	Total
Western harvest mice	3	10	18	31
Deer mice	24	18	9	51
California voles	17	13	6	36
Ornate shrews	10	7	11	28
House mice	6	4	5	14
Valley pocket gophers	1	5	9	15

Total animals collected = 176 over 3,744 trap nights.
Trapping success = 4.7%

Table 8-2
KESTERSON RESERVOIR
SMALL MAMMAL REPRODUCTIVE SUMMARY

SPECIES	Total Adults	Number Reproductive	Number Non-reproductive
Western harvest mice	31	23	8
Deer mice	40	26	14
California voles	34	15	19
Ornate shrews	27	22	5
House mice	14	7	7
Valley pocket gophers	15	12	3

65% of all small mammals collected were in reproductive condition.

SELENIUM CONCENTRATIONS

The results of selenium analysis of small mammals are presented in Appendix B. Geometric mean selenium concentrations in small mammals collected in 1989 ranged from 1.8 ppm (n=15; range=0.1-6.8) in pocket gophers to 21 ppm (n=27; range=9.3-125) in ornate shrews.

Comparisons were made between selenium concentrations from males and females of each species, reproductive and non-reproductive animals of each species, and adult and juvenile animals of each species. The only significant difference found was between male reproductive and non-reproductive western harvest mice (GM=7.0 ppm; n=18; range=3.9-29 and GM=3.7; n=3; range= 3.3-4.2, respectively).

California voles and ornate shrews had significantly higher geometric mean selenium levels than all other species collected, but they were not significantly different from each other. Valley pocket gophers and house mice had significantly lower geometric mean selenium levels than all other species collected, but were not statistically different from each other. The geometric mean selenium concentration in deer mice was not significantly different than geometric mean selenium levels in western harvest mice and house mice. Selenium levels in small mammals collected from Kesterson Reservoir are summarized in Table 8-3.

DISCUSSION

Adverse effects on reproduction of small mammals were not observed at Kesterson Reservoir in 1989. No relationship could be found between non-reproductive animals and high selenium levels. These results are consistent with the findings of Clark (1987).

In general, small mammals at Kesterson Reservoir reflected the selenium levels in their diets. Shrews and voles had the highest concentrations; ornate shrews are insectivorous and their tissues reflected the higher selenium levels in their invertebrate diet compared with lower levels found in vegetative material. California voles generally do not eat invertebrates, but the high levels found in some individual voles may be related to habitats with higher levels of selenium in the litter. Many of the California voles that had high selenium concentrations were trapped in open habitat or had debris in their stomach contents that is believed to be decomposing litter from the open habitat areas (ie., these are the areas with the highest selenium levels), indicating that they had been feeding in the open habitat. The litter in the open habitat is believed to be primarily decomposing cattail, but analysis has not yet been completed.

Table 8-3
KESTERSON RESERVOIR
SUMMARY OF SMALL MAMMAL
WHOLE BODY SELENIUM LEVELS
(ppm dry weight)

SPECIES	N	GEOMETRIC MEAN	RANGE
Western harvest mice			
1984 (1)	5	8.9	2.4 - 27
1987	24	4.0 (a)	0.6 - 13
1988	27	4.9	1.5 - 38
1989	31	6.3	2.7 - 29
Deer mice			
1987	36	5.7	1.0 - 34
1988	36	10 (a)	1.5 - 59
1989	40	4.8	1.1 - 15
California voles			
1984 (1)	5	7.3	1.4 - 33
1987	12	31	14 - 64
1988	9	8.1	3.2 - 15
1989	34	14	1.0 - 81
Ornate shrews			
1987	29	25	8.7 - 58
1989	27	21	8.7 - 125
House mice			
1989	14	4.1	2.2 - 9.7
Valley pocket gophers			
1989	15	1.8	0.1 - 6.8

(1) From Clark 1987
(a) Significantly different from 1989

The overall good condition of small mammals, even those with very high selenium concentrations as determined by gross necropsy and reproductive condition of most mammals, indicates that conditions at the Reservoir were not detrimental to small mammals in 1989. To date, no evidence of selenium toxicity to small mammals has been found at Kesterson Reservoir, although the high levels of selenium found in some small mammals may pose a threat to birds, mammals and reptiles that prey on them.

Chapter 9
PREDATOR COLLECTIONS AND ANALYSES FOR CONTAMINANTS

OBJECTIVES

The objective of this survey is to determine the selenium concentration in predators that forage at Kesterson Reservoir.

METHODS

Tomahawk live traps were pre-baited with canned cat food, mackerel, or tuna, at least one night prior to setting for predator trapping. Tracking medium was placed at the entrance to the trap to document visits to the traps. Three traps were placed in each trisection and set at sunset and checked at sunrise. Predator trapping did not coincide with small mammal trapping.

All predators (reptiles, birds, and mammals) salvaged on the Reservoir were necropsied to attempt to diagnose the cause of death. Animals are salvaged opportunistically from the Reservoir by USBR personnel. The stomach contents were identified when possible, and the liver was removed and frozen for future analysis.

RESULTS

Very few mammalian predators other than coyotes were observed at Kesterson Reservoir during the 1989 sampling season (Appendix A) and trapping was unsuccessful. Tracking medium placed at the entrance to the traps showed that out of 144 nights only 1 set of coyote and 1 set of long-tailed weasel tracks were observed.

A single coyote pup (about 4 months old), weighing 2.1 kg and measuring 38 cm from crown to rump, was salvaged from Kesterson Reservoir. No cause of death could be determined. The coyote had a heavy tick and flea infestation, but was otherwise healthy-looking. Only mucous and tapeworms were found in the stomach, but the coyote had normal fat and was not emaciated. Although it only had one kidney, the internal organs were normal and healthy in appearance. The liver was healthy in appearance and the liver selenium concentration in this animal was 3.4 ppm.

Two barn owls were salvaged in 1989 from Kesterson Reservoir. One owl salvaged from the area near the hazing compound (northwest Trisection 1) had an abrasion on the right leg and a broken right wing, possibly caused by a collision with a power line. The carcass was not fresh and a determination of the condition of the internal organs could not be made, although the bird did not appear to be emaciated. The selenium concentration in this bird's liver was 12.1 ppm. The cause of death could not be determined for the other owl; it appeared healthy and no injuries could be found. This bird was slightly desiccated but was not emaciated. The internal organs appeared normal, but the liver seemed slightly small. This owl was not reproductively active at the time of its death; its left testis measured 7 mm. This bird was salvaged in the north end of Trisection 3 and had a liver selenium concentration of 3.6 ppm.

DISCUSSION

The lack of water, the activity at the Reservoir, and changes in the habitat along with the large resident coyote population may account for the lack of other mammalian predators at Kesterson Reservoir. Skunks and raccoons were regularly observed in Kesterson Reservoir prior to filling, but were rarely seen in the Reservoir after filling (Chapter 10).

The three predators that were examined showed a wide range of selenium concentrations, but none of them exhibited any gross signs of selenium toxicity. The predators at Kesterson Reservoir do not necessarily forage primarily in the Reservoir. Many have a large home range in which Kesterson Reservoir may be included. For example, coyotes have a home range between 2,470 and 24,000 acres, so it is unlikely that coyotes would be foraging only in the Reservoir, which would also be reflected in their diet. It is impossible to say if the owls salvaged were foraging in the Reservoir, but it is unlikely that they would hunt exclusively in or outside of the Reservoir. The range of barn owls is not known, but is probably depends on the density of prey in an area.

Chapter 10
NIGHT SURVEYS

OBJECTIVES

The objectives of the night surveys are to determine the use of Kesterson Reservoir by nocturnal birds, mammals, and reptiles, and to document changes in the use of the Reservoir by these animals and the endangered San Joaquin kit fox.

METHODS

Night surveys were conducted twice a month, weather permitting, by driving along the canal and access roads in Kesterson Reservoir. One biologist drove slowly along the roads while another biologist used a 400,000-candle-power spotlight to detect animals and eyeshine from animals. A record was kept of all animals sighted in the Reservoir and in areas adjacent to the Reservoir during the survey.

RESULTS

A list of all mammals observed on the Reservoir in 1987 is presented in Appendix A-1. Black-tailed hares were observed most frequently during night surveys. Coyotes were the only mammalian predator that was regularly sighted; skunks, raccoons, and long-tailed weasels were seen infrequently during surveys. Barn owls were not observed during surveys until May and were commonly observed in subsequent months. Dogs and domestic cats were also observed on the Reservoir during surveys. No foxes were identified during any of the night surveys in 1989. The frequencies that animals were observed during the night surveys are presented in Table 10-1.

DISCUSSION

The results of the night surveys support the results of the attempted predator collections (Chapter 9) that few mammal predators, other than coyotes, were utilizing Kesterson Reservoir.

Table 10-1
KESTERSON RESERVOIR
1989 SUMMARY OF RESULTS OF NIGHT SURVEYS
CONDUCTED ON KESTERSON RESERVOIR

Date		Hare	Cotton-tail	Coyote	Raccoon	Skunk	Weasel	Barn Owl	Other*	Total
Jan-89	Survey total	29	5	7	0	0	0	0	7	**48**
	Frequency (%)	60	10	15	0	0	0	0	15	**11**
Feb-89	Survey total	32	15	11	0	2	0	0	3	**63**
	Frequency (%)	51	24	17	0	3	0	0	4	**14**
Mar-89	Survey total	38	29	3	0	0	0	0	0	**70**
	Frequency (%)	54	41	4	0	0	0	0	0	**16**
Apr-89	Survey total	29	7	6	0	0	0	0	3	**45**
	Frequency (%)	64	16	13	0	0	0	0	5	**10**
May-89	Survey total	7	7	6	1	0	1	4	1	**27**
	Frequency (%)	26	26	22	4	0	4	15	4	**6**
Jun-89	Survey total	18	2	2	0	0	0	8	4	**34**
	Frequency (%)	53	6	6	0	0	0	24	12	**8**
Jul-89	Survey total	14	12	5	3	0	3	13	1	**51**
	Frequency (%)	27	24	10	6	0	6	25	2	**12**
Aug-89	Survey total	23	3	5	1	2	1	23	9	**67**
	Frequency (%)	34	4	7	1	3	1	34	13	**15**
Sep-89	Survey total	18	3	1	0	1	1	8	5	**37**
	Frequency (%)	49	8	3	0	3	3	2	14	**8**
TOTAL		**208**	**83**	**46**	**5**	**5**	**6**	**56**	**33**	**442**
OVERALL FREQUENCY (%)		**47**	**19**	**10**	**1**	**1**	**1**	**13**	**8**	

* includes bats, dogs, cats and other unidentified mammals.

Chapter 11
SAMPLE HANDLING AND TRANSPORTATION/LABORATORY ANALYSES

SAMPLE HANDLING AND TRANSPORTATION

Disposable plastic bags or plastic buckets rinsed with uncontaminated water were used to transport materials to the laboratory. The samples were sorted using stainless steel or teflon forceps in glass or white enamel pans. All sorting equipment was rinsed with uncontaminated water after processing material from each sampling location.

After processing, each sample was placed in a chemically cleaned polyethelyne bottle and double labeled with its unique code indicating taxon, collection date, pond number, habitat type, and sampling site number. The code was written in indelible ink on the bottle and on a tie-on (string) tag secured to the neck of each bottle. This same information was also transcribed onto preformatted data sheets. The sealed, numbered samples were grouped by taxa and frozen immediately after sorting.

The frozen samples were packaged to avoid dead air space in sturdy, insulated shipping boxes filled with dry ice (about one-third of the total package weight). A transfer of custody form accompanied the samples to the analytical laboratory. This form was signed and dated by both the sender and the recipient. The samples were shipped to the analytical laboratories by overnight delivery.

LABORATORY ANALYSIS AT ENVIRONMENTAL TRACE SUBSTANCE RESEARCH CENTER (ETSRC)

Samples of both plant and animal tissue were analyzed for selenium content by hydride generation and atomic absorption on a Varian VGA-76 system at ETSRC. Samples were prepared by lyophilization (freeze-drying), homogenization, and digestion. Lyophilization data were used to calculate percent moisture in all samples. Selenium detection limits were 0.1 to 0.3 ppm (dry weight basis) in a sample of at least 0.5 g sample material. ETSRC's quality control and quality assurance procedures include:

1. Duplicate analyses of 10 percent of samples
2. Analysis for recovery of spiked amounts in 10 percent of samples
3. Blank samples to assess contamination (one with every 20 samples)
4. Blind reference standards in every sample group
5. Detailed tracking of all samples through the analysis steps

LABORATORY ANALYSIS OF KESTERSON SOILS

The extracts used in the total water extractable selenium analysis were made using a 5:1 water to dry mass ratio following procedures described in previous progress reports by LBL.

KESTERSON RESERVOIR
1990 BIOLOGICAL MONITORING PLAN

INTRODUCTION

The 1989 biological monitoring plan encompasses biological surveys and analyses to be conducted at Kesterson Reservoir between October 1, 1989 and September 30, 1990. The plan includes the following major elements:

- o Habitat Description
- o Vegetation/Invertebrate/Soil Sampling and Analyses
- o Bird Censusing
- o Bird Nesting Survey and Reproduction Analyses
- o Bird Collections and Analyses for Contaminants
- o Reptile Collections and Analyses for Contaminants
- o Small Mammal Collections and Analyses for Contaminants
- o Predator Collections and Analyses for Contaminants, and
- o Night Surveys

OBJECTIVES

The objectives of the biological monitoring program are as specified in the State Water Resources Control Board Order No. WQ 88-7:

1. Assess the impact of Kesterson Reservoir on local and migratory wildlife.

2. Provide a basis for adjusting Kesterson Reservoir management.

3. Verify the effectiveness of cleanup actions at Kesterson Reservoir.

4. Provide a basis for modifying future biological monitoring.

HABITAT DESCRIPTION

In order to effectively sample the different kinds of organisms that will occur at Kesterson Reservoir, it is necessary to recognize the macro habitats that are present at the site. The following habitat types are currently present at Kesterson Reservoir.

1. Grassland--unfilled areas dominated by saltgrass.

2. Filled--former wetland areas filled with soil in 1988. These areas are now dominated by annual plant species such as burning bush and introduced annual grasses.

3. Open--former cattail areas not filled. These former cattail areas are now sparsely vegetated with burning bush, prickly lettuce, and clover.

4. Intermittent Rainwater Puddles--ephemeral pools caused by rainfall, particularly in the filled and open areas.

During the sampling period, 1:24,000 aerial photographs will be taken of Kesterson Reservoir. Mapping of habitat types will be completed with the use of aerial photo interpretation. The habitat maps will be finalized by ground-truthing to verify or correct habitat identifications. Also, USBR biologists will note the location and extent of any ephemeral pools that may form.

VEGETATION/INVERTEBRATE/SOIL SAMPLING AND ANALYSES

OBJECTIVES

The primary objective is to determine the level of selenium contamination in abundant vegetation and invertebrates at Kesterson Reservoir. Soil samples will be analyzed to determine the selenium concentration available to plants through the soil.

SAMPLING FREQUENCY

The peak period of potential wildlife exposure to contaminants at Kesterson Reservoir occurs during the overwintering period from the middle of December to the end of February, and the reproductive (nesting) season from about the middle of March to the end of June. Samples will be collected once for each species during this time period. The actual times when sampling occurs for each species will vary depending on weather, plant and invertebrate growth, and wildlife use of the Reservoir. This will result in continued sampling throughout the peak periods of potential wildlife exposure.

SAMPLING LOCATIONS

For sampling purposes, Kesterson Reservoir has been divided into three trisections: The southern trisection (ponds 1, 2, 3, and 4), the central trisection (ponds 5, 6, 7, and 9), and the northern trisection (ponds 8, 10, 11, and 12). A minimum of six stations will be sampled in each macro habitat occurring in each trisection.

Where feasible, sampling locations will remain the same as locations sampled in the past. Sampling sites will be chosen by USBR and USFWS biologists during peak wildlife activity and plant growth times. Biological monitoring will also be conducted in research plots as part of the individual research programs complementing this plan.

SAMPLING METHODS

Vegetation

Above ground material will be clipped from living plants no less than ½ inch above the soil level. If seeds are present, they will be collected along with above ground material and sorted from the vegetative material. Samples will be collected from a sufficient number of plants (at least three) to provide at least 2 g wet weight each of seed and vegetative material. Plant species to be sampled will be chosen during presampling reconnaissance with USFWS personnel based on abundance and importance to wildlife.

Invertebrates

Terrestrial invertebrates will be collected by pitfall traps, sweep nets, and hand collection. In order to collect ground foraging insects, pitfall traps will be set at each sample site. Moist soil and grass will be placed at the bottom of the traps and a cover will be placed above the trap opening for protection from the elements. Sweep nets will be used to collect terrestrial insects that forage above the ground in the vegetation.

Active searching (e.g. turning over rocks, boards, and debris found in the trisections, and plywood placed there) will also be used as a collection method. Aquatic invertebrates will be collected from pools that occur by moving a rectangular aquatic kick-net through sediments and submergent vegetation which have been disturbed by kicking. A sufficient number of invertebrates will be collected to provide at least 2 grams wet weight of each sample whenever possible. All invertebrates collected will be placed into labeled ziplock plastic bags or plastic jars and frozen. The samples will then be sorted and identified.

Soil

Soil samples will be collected at each sample station. The soil will be collected by inserting a 2 cm core about 15 cm into the soil. Each sample will consist of a composite of three samples collected within a radius of about 25 feet of the station center. The samples collected will be shipped to Lawrence Berkeley Laboratory (LBL) for analysis of the total water extractable selenium.

BIRD CENSUSING

OBJECTIVES

The purpose of this census is to identify the species of birds using Kesterson Reservoir, estimate the number of birds using the Reservoir each month, and document changes of species composition and density over time.

METHODS

The bird survey will consist of two parts. USBR biologists will continue estimating "daily averages" and "use days" for killdeer, raptors, blackbirds, swallows, and other bird species. Transect counts will be used to estimate long-term changes in bird use for western meadowlarks, horned larks, sparrows, and other upland bird species at Kesterson Reservoir.

Monitoring long-term changes in bird numbers will be done using point or transect counts (Dawson 1981). A walking census of premarked belt (strip) transects will be made to determine bird species occurrence and species density at least twice every month (weather permitting). Fixed transect belts will be used to decrease variability by the observer. The same belts marked inside each trisection with stakes and flagging for the 1989 censuses will be used for the 1990 censuses. The patchiness of the macro habitats at Kesterson Reservoir will cause variation in estimates of bird numbers. To reduce the variation, belts will be cut into 50-meter-long intervals, further delineating the habitats. All birds seen or heard within the transect belts will be counted, identified, and recorded on preformatted data sheets including the following data: date, time census begins and ends, transect identification, interval identification (type of habitat), species observed, and the number of individuals of each species seen or heard. Strip censuses will commence at sunrise and observations will end about 4 hours later.

Density will be calculated by: $D = n/2LW$; (D = density, n = number of observations; L=transect (interval) length; W = transect width) (Emlen 1971). Relative abundance will be calculated by using the proportion of total birds of each species compared to the number of all birds of all species observed (Call 1982; Dawson 1981). Monthly population estimates will be calculated by multiplying the estimated density per acre of the species in the transect by the number of acres of the habitat type used by the species in the transect's corresponding trisection.

BIRD NESTING SURVEY AND REPRODUCTION ANALYSIS

OBJECTIVES

The objectives of the nesting survey are to assess the reproductive success of birds at Kesterson Reservoir by determining the frequencies of embryonic mortalities and developmental abnormalities, and the hatching success and fledging success of birds nesting at Kesterson Reservoir in spring and summer of 1990.

SURVEY DESIGN

Nest Searches

From mid-February until early July 1990, biologists will search for and monitor nests of birds including, but not limited to, killdeer (Charadrius vociferus), lesser nighthawk (Chordeiles acutipennis), northern harrier (Circus cyaneus), ring-necked pheasant (Phasianus colchicus), horned lark (Eremophila alpestris), and western meadowlark (Sturnella neglecta) that occur at Kesterson Reservoir. Western meadowlark nests will be located by observing activities of birds in nesting habitats. When nests are not found by search and observation in active territories, the nests will be pinpointed by dragging a chain through the grass. This method has been used successfully at Kesterson Reservoir for locating western meadowlark nests and has been used by USFWS personnel in the past to locate waterfowl nests (Ohlendorf, H.M. personal communication). It is a modification of the method described by Higgins et al. (1977; Higgins et al. 1969; Klett et al. 1986).

The levee roads will be searched for killdeer, lesser nighthawk, and other nests. These birds are usually visible from the roads surrounding the ponds, nests will be keyed in on by driving slowly along the levee roads and watching for the adult leaving the nest, displaying, or "sneaking." When the birds are located, one biologist will sight the nest and direct the second biologist to its location.

Nest Monitoring

After a nest is found, it will be marked with flagging approximately 10 feet away from the nest, mapped, and given a unique code. Nest codes will include four-letter species acronyms, the pond number, and a nest number. For example, CHVO 5-1 will indicate the first killdeer nest found at Pond 5, and CHVO 7-2 will indicate the second killdeer nest found at Pond 7. Monitoring of the nest will begin immediately after its discovery and continue on a weekly basis to assess hatching success, nestling survival, and fledging success. Every effort will be made to minimize disturbance to the nesting birds. Each week the date, nest code, and number of eggs will be recorded on data sheets. We will also attempt

to determine if the embryo is alive or dead and the approximate embryonic stage of development by candling the eggs with a modified flashlight or radiator hose (Weller 1956; Klett et al. 1986).

Egg Collections

One egg will be removed immediately after a nest is located and opened to verify the developmental stage estimated by candling. The contents of the egg will be saved for residue analysis. If an egg is removed from a nest before the clutch is completed or soon after the clutch is completed, some birds will lay another egg and complete the clutch. Gross embryonic abnormalities are easiest to detect at late stages of development. Therefore, if the embryo in the first egg removed from a nest is not sufficiently developed to detect abnormalities, a second egg may be removed. At collection, each egg will be marked with its nest code and the date it was removed. The data will be recorded on a data sheet and the egg will be placed into a container to avoid damage. All eggs removed from nests will be examined or refrigerated within 1 hour of collection. The eggs will remain refrigerated until they are examined. If we are unable to determine whether the embryo is alive by candling, the egg will be examined within 1 or 2 days of collection.

Laboratory Examinations

All eggs collected will be examined as soon after collection as possible. Each egg will be opened to determine its fertility, stage of development, the position of the embryo, and whether pipping (internal pipping into the air cell or external pipping of the shell) has occurred. Each embryo will also be examined for evidence of external deformities and other abnormalities. The entire egg contents will be saved in chemically cleaned containers and frozen.

BIRD COLLECTIONS AND ANALYSES FOR CONTAMINANTS

OBJECTIVES

Individuals of selected species of birds will be collected to determine their feeding habits and selenium concentration in their livers. Birds that are found dead and salvaged will be necropsied and their livers analyzed for selenium concentration. This information will be compared to information obtained in other years to document the levels and effects of selenium on the terrestrial birds at Kesterson Reservoir.

METHODS

Bird Collection

Western meadowlarks (Sturnella neglecta), white-crowned sparrow (Zonotrichia leucophrys), and red-winged blackbirds (Agelaius phoeniceus) will be collected by gun during the spring sampling period if they are present on the Reservoir in large numbers; if these species do not occur in high numbers at Kesterson Reservoir in 1990, other species will be considered. If possible, three or four birds of each target species will be collected from each trisection at the end of the nesting season. Western meadowlarks are insectivorous birds that remain at Kesterson Reservoir year round. White-crowned sparrow are seed eating birds that are absent from Kesterson in the summer months. Red-winged blackbirds are opportunistic in their feeding habits and are in the Kesterson area all year, but they may be scarce during the nesting period due to the lack of suitable nesting habitat at Kesterson. A maximum of 10 individuals of each target species will be collected. The location of collection will be recorded for each bird. Birds found dead on the reservoir will be salvaged and frozen. These birds will be necropsied to attempt to determine cause of death.

Sample Preparation

Each carcass will be weighed and dissected. The reproductive condition of each bird will be noted, the left testis will be measured in males, the crop and gizzard contents will be identified, and any gross abnormalities of the internal organs will be noted. The liver will be removed from each animal, weighed and placed in a labeled, chemically cleaned container and frozen. The remainder of the carcass of salvaged birds will be saved and made available to the USFWS.

REPTILE COLLECTIONS AND ANALYSES FOR CONTAMINANTS

OBJECTIVES

The objective of this survey is to document the levels of selenium in the common reptiles and amphibians found at Kesterson Reservoir. Reptiles and amphibians are a part of the prey base for carnivorous mammals and predatory birds that forage at Kesterson Reservoir.

METHODS

Reptile Collection

Reptiles will be collected opportunistically throughout the year, depending on their availability at Kesterson Reservoir. The target species we expect to collect

if they occur in high numbers at Kesterson Reservoir are: side-blotched lizard (Uta stansburiana), western fence lizard (Sceloporus occidentalis), and gopher snake (Pituophis melanoleucus). When captured, samples of the less common kingsnake (Lampropeltis getulus) will be taken. The endangered blunt-nosed leopard lizard (Gambelia silus) and federal candidate species California Tiger Salamander (Ambystoina californiense) may occur in the collection area but will not be collected. Pitfall traps will be checked frequently and any nontarget species trapped will be released. We will attempt to collect a maximum of three individuals of each target species from each trisection.

In order to enhance collecting success and repeatability of collections from saltgrass areas, 4-foot by 4-foot sheets of plywood and corrugated sheet metal will be placed in saltgrass areas within each trisection. Pitfall or can traps with field fencing will also be set up. Reptiles and amphibians will be collected using a combination of opportunistic and systematic collecting methods such as: road riding; shooting; noosing; pitfall or can trapping; and hand catching. Active searches for reptiles and amphibians will be made by turning over rocks, boards, and other debris (Call 1982; Stebbins 1966).

Sample Preparation

All reptiles and amphibians will be sexed and weighed. Total body (snout-vent), tail, and right hind foot length of lizards will be measured and recorded. Total length of snakes and total body (snout-vent), and right hind foot length of toads collected will be measured and recorded. Reptiles and amphibians will be frozen in chemically cleaned, labeled containers. Each carcass will be dissected and the reproductive condition of each animal will be determined.

The liver and the remainder of the carcass from each animal will be analyzed separately for selenium. The liver will be removed from each animal, weighed and placed in a labeled sample container. Food will be removed from the digestive tract and each carcass will be placed in a separate labeled sampled container.

SMALL MAMMAL COLLECTIONS AND ANALYSES FOR CONTAMINANTS

OBJECTIVES

The objectives of this survey are to: 1) document the levels of selenium in small mammals at Kesterson Reservoir; and 2) demonstrate the route of selenium accumulation in small mammals by determining food habits. Small mammals are the major prey base for higher trophic-level birds, reptiles, and mammals, including the San Joaquin kit fox.

METHODS

Trapping Methodology

Mammals will be trapped annually from February to July each trisection. Nine trap-line locations will be selected along the bird census transects in each trisection. Bird censusing and mammal trapping will overlap. Setting and collecting traps will not be done while the census is being conducted. Museum Special snap-traps will be baited with peanut butter and placed at 10-meter intervals along each transect line for trapping deer mice (Peromyscus maniculatus) and western harvest mice (Reithrodontomys megalotis). For California voles (Microtus californicus), Museum Special snap-traps will be placed on runways and around bushes where signs are found adjacent to the trap-lines. Valley pocket gopher (Thomomys bottae) will be collected from each trisection in which they are found using kill traps set in active tunnels. Ornate shrews (Sorex ornatus) will be analyzed for selenium when at least three individuals are captured in a trisection. Selenium levels of mammals collected in the past from either Volta Wildlife Area, San Luis Wildlife Refuge, or Grasslands in Merced County will be used for baseline selenium level reference.

Analysis of Stomach Contents

The stomach contents of animals collected will be examined microscopically to identify plant fragments to determine their diet. Rodents chew vegetation very finely making identification by gross examination impractical; a staining procedure will be used for identifying plant material. Material from the stomachs of animals collected will be stained and matched against a reference set for identification (Westoby et al. 1976; Williams 1962). Stomach content identification will be done with the assistance of the Composite Analysis Laboratory of Colorado State University.

Reproductive status of males will be determined by testes size and location. Status and productivity of females will be determined by measurements of uterine width, implantation scars, corpora lutea, and follicle counts, as well as by the presence or absence of embryos, and embryo size (Christian 1950; Conaway 1955). All animals will be weighed. Total body (head-tail), tail, right hind foot, and right ear lengths will be measured and recorded. Animals will be frozen for future analyses.

Sample Preparation

Ten individuals of each collected target species will be selected from each trisection for laboratory analysis to determine selenium content. Individuals will be randomly selected for selenium analysis from trap lines throughout each trisection.

Digestive tracts from each animal will be severed at the esophageal and pyloric sphincters. Stomachs will be opened lengthwise beginning at the pylorus, and the contents will be removed. Stomach contents will be removed for identification of food items. Each stomach will then be placed with the respective animal in chemically cleaned sample containers. The liver will be removed from each carcass. The liver and carcasses of each animal will be analyzed separately for selenium concentration. Whole body selenium levels for individuals will be calculated by weight. Samples will be weighed, labeled, and refrozen.

PREDATOR COLLECTIONS AND ANALYSES FOR CONTAMINANTS

OBJECTIVES

Predators that may occur at Kesterson Reservoir are exposed to selenium through their prey. The objective of this survey is to determine the selenium concentration in predators that forage at Kesterson Reservoir.

METHODS

Coyotes (Canis latrans), skunks (Mephitis mephitis), and raccoons (Procyon lotor) will be live-trapped from each trisection in which they occur. A maximum of 10 individuals of each species will be trapped. Other predators which may be trapped are longtail weasels (Mustela frenata), red fox (Vulpes fulva), gray fox (Urocyon cinereoargenteus), oppossums (Didelphis virginianus), and badgers (Taxidea taxus). Each trap will be checked as soon after sunrise as possible. Animals trapped will be sedated in the trap. Blood and fur samples will be taken for selenium analysis. The age of each animal trapped will be estimated (as adult or juvenile). Total body (head-tail), tail, right hind foot, and right ear lengths will be measured and recorded. The animal will be sexed, weighed, marked, and released when it recovers from the anesthetic. If kit fox (Vulpes macrotis) are captured, only a hair sample will be taken prior to release.

If predator trapping is not successful, alternative action will be taken. One possible alternative to be considered is shooting coyotes on the Reservoir. This and other alternatives will be discussed with USFWS and USBR biologists.

Avian predators that have been regularly observed foraging at Kesterson Reservoir include red-tailed hawks (Buteo jamaicensis), northern harriers (Circus cyaneus), barn owls (Tyto alba), and great horned owls (Bubo virginianus). Less common hunters and winter visitors at Kesterson include prairie falcons (Falco mexicanus), merlins (Falco columbarius), American kestrels (Falco sparverius), and black-shouldered kites (Elanus leucurus). These birds will be live-trapped on Kesterson Reservoir throughout the year. A blood sample will be taken for

selenium analysis. The age of the individual will be estimated (as adult or juvenile) and the condition (health, condition of the feathers, etc.) of the bird will be recorded. The bird will then be released.

NIGHT SURVEYS

OBJECTIVES

Night surveys will be conducted at Kesterson Reservoir to determine the use of the Reservoir by nocturnal birds, mammals, and reptiles. These surveys may also allow us to document changes in the use of Kesterson Reservoir by the endangered San Joaquin kit fox.

METHODS

Night surveys will be conducted at least twice a month (weather permitting) by driving along the canal and access roads in Kesterson Reservoir. One biologist will drive slowly along the road while another biologist uses a spotlight to detect animals and eyeshine from animals. The entire Reservoir will be searched in this way. A record will be kept of all bird, mammal, and reptile observations made during the night survey, both on the reservoir and on the adjacent areas observed from the Reservoir. If kit fox use increases at the Reservoir, the frequency of surveys will be re-evaluated.

SAMPLE HANDLING AND TRANSPORTATION

All sample containers will be doubly labeled: indelible ink will be used directly on the container, and a second label will be placed in the container. Every sample will receive a unique code which will be transcribed onto preformatted data sheets. The sealed, numbered samples will be grouped by taxa and frozen immediately after sorting or collection and will remain frozen until they are packaged for shipping.

Frozen samples will be grouped by taxa and packaged to avoid dead air space in sturdy, insulated shipping boxes filled with dry ice. A transfer of custody form will accompany the samples to the analytical laboratory. This form will be signed and dated by both sender and recipient. The samples will be shipped by Federal Express or delivered directly to the laboratory.

REPORTING

A final report will be prepared. This final report will summarize the results of the current year's biological monitoring program. These results will be compared with results from biological monitoring conducted in the past at Kesterson Reservoir and with results from research programs.

The results of the biological monitoring program will be used to:

- Describe existing biological conditions at Kesterson Reservoir.
- Assess the impact of Kesterson Reservoir on the local biological community, including migratory birds.
- Describe an adjusted (if appropriate) biological monitoring plan for the next year.
- Provide a basis for adjusting Kesterson Reservoir management, if appropriate.

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PERSONAL COMMUNICATIONS

21. Benson, S. Staff Scientist, Lawrence Berkeley Laboratory.

22. Ohlendorf, H.M. Research Biologist, USFWS, Pacific Coast Field Station. Patuxent Wildlife Research Center, Davis, California.

APPENDIX A

Appendix A-1

PLANT SPECIES IDENTIFIED AT KESTERSON RESERVOIR IN 1989

Common Name	Scientific Name
Red brome	Bromus rubens
Ripgut brome	Bromus rigidus
Soft chess	Bromus mollis
Foxtail fescue	Festuca megalura
Saltgrass	Distichlis spicata
Ryegrass	Lolium spp.
Common sicklegrass	Pholiurus incurvus
Wild oats	Avena spp.
Alkali sacaton	Sporobolus airoides
Mediterranean barley	Hordeum hystrix
Wild barley	Hordeum spp.
Beardgrass	Polypogon spp.
Bulrush	Scirpus spp.
Rush	Juncus spp.
Curly dock	Rumex crispus
Lambsquarters goosefoot	Chenopodium album
Saltbush	Atriplex spp.
Summercypress (burning b	Kochia spp.
Iodinebush	Allenrolfia occidentalis
Prostrate pigweed	Amaranthus graecizans
Red maids	Calandrinia caulescens
California poppy	Eschscholzia californica
Wild mustard	Brassica campestris
Black mustard	Brassica nigra
Lupine	Lupinus spp.
Bur clover	Medicago hispida
Annual yellow sweetclover	Melilotus indica
White sweetclover	Melilotus alba
True clover	Trifolium spp.
Trefoil	Lotus spp.
Whitestem filaree	Erodium moschatium
Redstem filaree	Erodium cicutarium
Alkali mallow	Sida hederacea
Alkali heath	Frankenia grandifolia
Bindweed	Convolvulus spp.
Dodder	Cuscuta spp.
Salt heliotrope	Heliotropium curassavicum

Appendix A-1

PLANT SPECIES IDENTIFIED AT KESTERSON RESERVOIR IN 1989

Common Name	Scientific Name
Fiddleneck	Amsinchia spp.
Vinegarweed	Trichostema lanceolatum
Purple owlsclover	Orthocarpus purpurascens
Plantain	Plantago spp.
Prickly lettuce	Lactuca scariola
Snakeweed	Gutierrezia spp.
Gumweed	Grindelia camporum
Slender aster	Aster exilis
Common sunflower	Helianthus annuus
Blow-wives	Achyrachaena mollis
Goldfields	Baeria spp.
Pineappleweed	Matricaria spp.
Brassbuttons	Cotula spp.
Common groundsel	Senecio vulagaris
Thistle	Cirsium spp.
Yellow starthistle	Centaurea solstitialis
Common spikeweed	Hemizonia pungens
Fitch's spikeweed	Hemizonia fitchii
Nightshade	Solanum spp.
Horseweed fleabane	Erigeron (conyza) canadensis
Willow-herb	Epilobium paniculatum
Cocklebur	Xanthium strumarium
Fivehook smotherweed	Bassia hyssopitolia
Mayweed	Anthemis cotula
Scarlet pimpernel	Anagallis arvensis
Beardless wildrye	Elymus triticoides
Shortpod mustard	Brassicageniculata
Alkaliweed	Cressatruxillensis
Nettleleaf goosefoot	Chenopodium murale
Purslane	Portulaca spp.

Appendix A-2

BIRD SPECIES SIGHTED AT KESTERSON RESERVOIR IN 1989

Common Name	Scientific Name
Mallard	Anas platyrynchos
Killdeer	Charadrius vociferus
Black-shouldered kite	Elanus leucurus
American kestrel	Falco sparverius
Merlin	Falco columbarius
Red-tailed hawk	Buteo jamaicensis
Northern harrier	Circus cyaneus
Ring-necked pheasant	Phasianuscolchicus
Mourning dove	Zenaidura macroura
Barn owl	Tyto alba
Lesser nighthawk	Chordeiles acutipennis
Grasshopper sparrow	Ammodramus savannarum
Song sparrow	Melospiza melodia
Savannah sparrow	Passerculus sandwichensis
Golden-crowned sparrow	Zonotrichia atricapilla
White-crowned sparrow	Zonotrichia leucophrys
House finch	Carpodacus mexicanus
Blue grosbeak	Guiraca caerulea
Long-billed marsh wren	Telmatodytes palustris
Northern mockingbird	Mimus polyglottos
Western meadowlark	Sturnella neglecta
Yellow-rumped warbler	Dendroica coronata
Western kingbird	Tyrannus verticalis
Black phoebe	Sayornis nigricans
Barn swallow	Hirundo rustica
Tree swallow	Tachycineta bicolor
Red-winged blackbird	Agelaius phoeniceus
Tricolored blackbird	Agelaius tricolor
Brewer's blackbird	Euphagus cyanocephalus
Brown-headed cowbird	Molothrus ater
Water pipit	Anthus spinoletta
Loggerhead shrike	Lanius ludovicianus

Appendix A-3

MAMMALS OBSERVED AT KESTERSON RESERVOIR IN 1989

Common Name	Scientific Name
Virginia opossum	Didelphis virginianus
Ornate shrew	Sorex ornatus
California ground squirrel	Spermophilus beecheyi
Heerman's kangaroo rat	Dipodomys heermani
Western harvest mouse	Reithrodontomys megalotis
Deer mouse	Peromyscus maniculatus
California vole	Microtus californicus
House mouse	Mus musculus
Coyote	Canis latrans
Raccoon	Procyon lotor
Long-tailed weasel	Mustela frenata
Badger	Taxidea taxus
Striped skunk	Mephitis mephitis
Desert cottontail	Sylvilagus audubonii
Black-tailed jack rabbit	Lepus californicus

APPENDIX B-1

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali heath (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		12	12
Range		1.7-18	0.1-15
Geometric Mean		5.1	3.2
Fall 1988			
N	3	3	3
Range	2.3-7	2.1-6.8	1.3-8.2
Geometric Mean	4.8	3.7	3.0
Winter 1989			
N	3	3	3
Range	2.3-4.8	2.4-3.5	2.3-7.7
Geometric Mean	3.3	2.9	3.6
Spring 1989			
N	6	6	6
Range	1.2-32	2.1-16	1.1-12
Geometric Mean	4.1	5.7	2.8

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali heath (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range			
Geometric Mean			
Summer 1989 N Range	6 0.4-22	6 1.1-12	3 7.2-28
Geometric Mean	2.9	3.2	12.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali heath (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 0.7-10	5 2.1-6.7	6 0.4-6.4
Geometric Mean	2.8	3.9	1.8

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali weed (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		12	12
Range		2.5-9.4	1.9-11
Geometric Mean		5.6	4.3
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	1.9-8.3	1.7-7.4	0.9-8.5
Geometric Mean	3.9	4.3	2.6

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali weed (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range			6 1.0-17
Geometric Mean			3.7
Summer 1989 N Range	6 2.8-20	6 1.6-29	6 2.2-13
Geometric Mean	6.7	7.7	5.1

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Alkali weed (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	5	4	6
Range	1.5-9.1	1.0-4.3	0.9-4.1
Geometric Mean	4.3	2.2	1.5

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Annual grasses (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N	3	3	3
Range	1.2-1.7	0.7-2.0	0.7-2.9
Geometric Mean	1.4	1.0	1.5
Spring 1989			
N	6	6	6
Range	0.3-9.2	0.2-7.8	0.4-9.4
Geometric Mean	1.1	0.9	2.4

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Annual grass (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 4.6-38	5 3.3-13	6 1.2-16
Geometric Mean	8.5	8.0	4.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Annual grass seed (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 0.4-4.1	6 0.2-5.8	6 0.4-7.0
Geometric Mean	1.2	0.8	1.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Annual grass seed (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 3.9-13	5 3.9-10	6 2.8-8.2
Geometric Mean	6.9	6.4	5.1

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Burning bush (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		11	11
Range		0.2-3.7	0.5-3.0
Geometric Mean		1.3	1.1
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N			
Range			
Geometric Mean			

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Burning bush (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	5 0.2-13	6 0.8-16	6 0.1-8.6
Geometric Mean	2.7	3.3	2.0
Summer 1989 N Range	6 0.7-4.7	6 1.8-12	6 0.9-9.8
Geometric Mean	2.5	3.7	2.9

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Burning bush (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	2.2-16	0.6-12	1.0-8.4
Geometric Mean	5.1	3.3	2.5
Summer 1989			
N	6	6	6
Range	0.4-5.3	0.6-10	0.3-1.3
Geometric Mean	1.5	1.6	0.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Clover (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	5 0.2-11	6 0.7-13	6 0.4-10
Geometric Mean	0.9	1.5	1.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Clover (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N	3	3	3
Range	11-27	11-15	6.1-19
Geometric Mean	15.3	12.9	9.5
Spring 1989			
N	6	6	6
Range	1.4-17	2.7-18	2.3-14
Geometric Mean	8.7	6.0	6.6

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Clover seed (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	0.3-5.9	1.0-18	0.6-14
Geometric Mean	1.5	2.3	3.0

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Clover seed (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	2.9-25	4.5-13	4.4-10
Geometric Mean	11.8	5.2	6.4

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Mustard (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 3.4-82	6 2.9-44	6 4.3-34
Geometric Mean	18.9	15.5	8.6

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Mustard seed (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 1.5-13	6 2.0-6.8	6 1.5-12
Geometric Mean	5.6	4.0	4.9

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Prickly lettuce (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	3.7-11	4.5-13	1.2-20
Geometric Mean	6.8	8.2	4.0

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Prickly lettuce (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	6 1.8-12	6 1.3-5.4	6 1.5-18
Geometric Mean	5.8	3.5	3.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Prickly lettuce (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	3.9-16	3.0-6.7	1.7-6.3
Geometric Mean	7.5	4.9	3.9
Summer 1989			
N	6	6	6
Range	1.9-13	0.8-9.8	0.6-2.6
Geometric Mean	4.2	3.4	1.7

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Salt grass (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		12	12
Range		0.9-4.2	0.5-2.6
Geometric Mean		2.0	1.3
Fall 1988			
N	3	3	3
Range	2.7-6.8	1.6-3.6	0.8-2.7
Geometric Mean	5.0	2.5	1.8
Winter 1989			
N	3	3	3
Range	4.9-8.6	1.4-4.2	0.8-6.6
Geometric Mean	6.5	2.1	2.8
Spring 1989			
N	6	6	6
Range	1.5-6.4	0.6-4.1	0.6-8.0
Geometric Mean	3.2	2.5	1.5

Kesterson Reservoir
Plant Selenium Concentrations
(ppm dry weight)

Sample Type: Saltgrass seed (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		10	12
Range		0.6-6.5	0.4-15
Geometric Mean		1.8	1.4
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	6	6
Range	0.7-4.7	0.5-2.7	0.2-3.5
Geometric Mean	1.7	1.5	0.7

APPENDIX B-2

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Beetles (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		8	9
Range		7.2-31	5-16
Geometric Mean		10.2	8.6
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	4	5
Range	4.6-22	12-42	5.0-19
Geometric Mean	13.6	19.3	9.3
Summer 1989			
N	2	1	
Range	16-25	1.9	
Geometric Mean	20	1.9	

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Beetles (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	 4 8.6-19	 3 9.1-26	 4 6.8-17
Geometric Mean	13.1	14.5	9.2
Summer 1989 N Range			 2 0.1-10
Geometric Mean			1

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Beetles (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	5	5	5
Range	10-40	11-41	8.3-16
Geometric Mean	23.9	18.5	10.7
Summer 1989			
N	2		1
Range	12-27		16
Geometric Mean	18		16

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Crickets (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		6	6
Range		2.9-27	31115.0
Geometric Mean		9.8	6.1
Fall 1988			
N	3	2	2
Range	7.3-12	19-21	31047.0
Geometric Mean	9.9	20.0	1.0
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	4	4	1
Range	5.7-8.4	4.1-11	3.2
Geometric Mean	6.6	6.3	3.2

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Crickets (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	3 3.9-6.7	1 3.5	5 9.6-23
Geometric Mean	5.4	3.5	16.9

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Crickets (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range		5 6.3-22	4 6.4-11
Geometric Mean		12.5	8.8

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Grasshoppers (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		12	12
Range		2.8-7.8	1.9-8.3
Geometric Mean		4.9	3.7
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	4	3	4
Range	2.9-16.0	2.0-12.0	2.8-7.5
Geometric Mean	5.6	5.3	4.5
Summer 1989			
N	4	2	5
Range	2.7-3.5	3.7-5.5	2.1-5.5
Geometric Mean	3	4.5	3.5

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Grasshoppers (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	3	4	5
Range	1.0-7.4	2.2-9.6	0.7-7.3
Geometric Mean	1.9	4.8	2.2
Summer 1989			
N		3	1
Range		4.3-5	4.8
Geometric Mean		4.6	4.8

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Grasshoppers (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	5 3.5-9.6	6 2.0-12	5 5.8-25
Geometric Mean	5.5	4.8	8.4
Summer 1989 N Range	2 8.3-14		
Geometric Mean	10.8		

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Mixed aerial (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	6	5	6
Range	9.0-18.0	7.8-11.0	2.0-10.0
Geometric Mean	12.1	9.6	4.7
Summer 1989			
N	2	2	
Range	4.9-6.8	4.6-6	
Geometric Mean	5.8	5.3	

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Mixed aerial (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	 6 2.9-7.4	 6 3.5-8.3	 6 2.4-4.3
Geometric Mean	4.1	2.9	3.3
Summer 1989 N Range		 3 2-6.7	
Geometric Mean		3.6	

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Mixed aerial (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988 N Range			
Geometric Mean			
Fall 1988 N Range			
Geometric Mean			
Winter 1989 N Range			
Geometric Mean			
Spring 1989 N Range	 6 3.1-16	 6 2.8-9.8	 6 3.2-7.3
Geometric Mean	7.4	4.6	5.1
Summer 1989 N Range	 1 18	 1 3.6	 1 6.5
Geometric Mean	18	3.6	6.5

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Sowbugs (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		11	12
Range		47.-100.	23.-210.
Geometric Mean		69.6	48.2
Fall 1988			
N	3	3	
Range	59-86	23-56	
Geometric Mean	73	39	
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	5		
Range	59-75		
Geometric Mean	68		
Summer 1989			
N	5		
Range	36-87		
Geometric Mean	66		

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Sowbugs (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	1	1	
Range	84	74	
Geometric Mean	84	74	
Summer 1989			
N	1		
Range	120		
Geometric Mean	120		

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Spiders (Grassland)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N		12	13
Range		11-51	5.6-34
Geometric Mean		19.3	12.5
Fall 1988			
N		3	
Range		10-20	
Geometric Mean		13.8	
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N	4	2	
Range	13-40	13-16	
Geometric Mean	22.2	14.4	
Summer 1989			
N	2	1	
Range	18-34	5.4	
Geometric Mean	24.6	5.4	

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Spiders (Filled)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N		1	1
Range		30	21
Geometric Mean		30	21
Summer 1989			
N	5	2	2
Range	6-26	2-6.3	3.8-4.3
Geometric Mean	14.6	3.6	4.0

Kesterson Reservoir
Invertebrate Selenium Concentrations
(ppm dry weight)

Sample Type: Spiders (Open)

	Trisection 1	Trisection 2	Trisection 3
Summer 1988			
N			
Range			
Geometric Mean			
Fall 1988			
N			
Range			
Geometric Mean			
Winter 1989			
N			
Range			
Geometric Mean			
Spring 1989			
N		1	2
Range		13	19-27
Geometric Mean		13.0	22.6
Summer 1989			
N	4	2	1
Range	4.9-40	3-5	61
Geometric Mean	14.1	3.9	61

APPENDIX B-3

Kesterson Reservoir
Selenium Concentration
(ppm dry weight)

Sample Type: Gopher Snake--Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1988			
N		1	
Range		33	
Geometric Mean		32.9	
1989			
N	2	1	3
Range	4-35	22	0.7-4.6
Geometric Mean	11.8	22.0	1.4

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: Western Harvest Mice--Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1984*			
N		5	
Range		2.4-27	
Geometric Mean		8.9	
1987			
N		12	12
Range		2.2-13	0.6-10
Geometric Mean		4.9	3.4
1988			
N	6	9	12
Range	8.-38	2.7-7.5	1.5-6.1
Geometric Mean	14.4	4.2	3.9
1989			
N	3	10	18
Range	18-23	4.3-8.8	2.7-13
Geometric Mean	22.6	5.5	5.5

* Clark, 1986.

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: Deer Mice -- Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1987			
N	12	12	12
Range	3.1-22	2.2-34	1-18.
Geometric Mean	10.3	6.6	2.7
1988			
N	12	12	12
Range	4-97	2.6-79	1.5-38
Geometric Mean	26.7	10.3	4.1
1989			
N	17	14	9
Range	2.7-15	1.3-9.9	1.1-6.2
Geometric Mean	7.8	3.6	3.2

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: California Voles -- Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1984*			
N	2	2	
Range	13-33	1.4-4.8	
Geometric Mean	20.7	2.6	
1987			
N	12		
Range	14-64		
Geometric Mean	32.3		
1988			
N	6	3	
Range	3.2-14	5-15	
Geometric Mean	8.5	7.4	
1989			
N	15	13	6
Range	4.2-45	1.0-81	5.0-33
Geometric Mean	18.9	9.3	7.8

* Clark, 1986.

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: Ornate Shrew--Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1984*			
N		4	
Range		10-100	
Geometric Mean			
1987			
N	1	15	13
Range	43	16-41	8.7-58
Geometric Mean	43	28.1	20.5
1988			
N			
Range			
Geometric Mean			
1989			
N	10	7	10
Range	11-125	9-55	15-26
Geometric Mean	25.1	18.7	20.0

* Clark, 1986.

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: House Mouse--Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1984*			
N	3	1	1
Range	8.2-44	9.1	3.4
Geometric Mean	21.6	9.1	3.4
1987			
N			
Range			
Geometric Mean			
1988			
N			
Range			
Geometric Mean			
1989			
N	5	4	5
Range	3.2-5.5	3.8-9.7	2.2-7.3
Geometric Mean	3.5	5.6	3.7

* Clark, 1986.

Kesterson Reservoir
Small Mammal Selenium Concentrations
(ppm dry weight)

Sample Type: Botta Pocket Gopher--Whole Bodies--

	Trisection 1	Trisection 2	Trisection 3
1984*			
N			
Range			
Geometric Mean			
1987			
N			
Range			
Geometric Mean			
1988			
N			
Range			
Geometric Mean			
1989			
N	1	5	9
Range	3	0.2-6.8	0.1-4.6
Geometric Mean	3	2.4	1.5

* Clark, 1986.

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